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A Correlation between Bacterial Flacherie and Alkaline Phosphatase Activity of the Midgut of Silk worm *Bombyx mori* L.

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Abstract: Bacterial flacherie is a very common disease of larvae of *B. mori*. In the present study an attempt has been made to correlate the pH of gut, activity of alkaline phosphatase and the bacterial infection in the midgut of 3rd, 4th and 5th instar larvae of three different races of *B. mori*. It has been observed that the midgut of healthy worm is highly alkaline and it has high activity of alkaline phosphatase. As the infection begins the pH of midgut changes and the activity of alkaline phosphatase decreases. The gut becomes highly acidic. The damage done to the epithelium, decreases the secretory activity which leads to the death or the coma.

Keywords: Bacterial flacherie, alkaline phosphatase, midgut, *B. mori*.

Introduction

High concentrations of alkaline phosphatase in the gut of *B. mori* have been shown by several workers (Nakamura, 1940; Sugai, 1957; Horie, 1958; Sridhara and Bhat, 1963). The properties of alkaline phosphatase in the digestive fluid of *B. mori* are not well explained although Sridhar and Bhat (1963) have shown that the increase of alkaline phosphatase in the midgut of 5th instar and its sudden appearance afterwards indicating towards its role in the transport of materials like glucose etc. across the intestinal wall. The midgut of lepidopteran larvae including *B. mori* is highly alkaline. The pH varies from 8 to 12 in most of the cases (Eguchi *et al.* 1972; Dow, 1984, 1986; Pringle, 1984). The alkaline nature of midgut is directly related to the secretion of alkaline phosphatase which is essential for the synthesis of certain protease enzymes for food digestion (Eguchi and Iwamoto, 1975).

Bacterial flacherie is a very common disease of larvae of *B. mori* obviously there is a close connection between alkalinity of the gut and flacherie disease. the infected worm has an acidic gut (Pringle, 1984) and therefore in the present study, an attempt has been made to correlate the alkaline phosphatase activity in the midgut of 3rd, 4th and 5th instar larvae of 3 races of *B. mori* and the gradual appearance of flacherie disease.

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Material and Methods

D. F. L's of three races of *B. mori* were collected from Govt. Seed Centre, Sonkatch (M. P.) and reared in the laboratory. The flacherie infected worms were collected from various silkworm rearing farms and infection causing bacteria were cultured in the laboratory. The leaves were infected by spraying a solution of approximately 1×10^5 bacterial/ml before providing to the worms. The infected leaves were provided to the worms just from 1st day onwards after second moult. The 4–day–old, 4th instar worms become sluggish and certain symptoms of flacherie disease appear in the beginning of 4th instar larvae.

The midguts of 3rd (3–day–old), 4th (4-day-old) and 5th (5-day-old) instar larvae were dissected out in cold normal saline. The midgut portion was separated and homogenized at cold conditions. A 10% homogenate in 0.25 M sucrose was centrifuged for 20 minutes at 900 g and the resulting supernatant was employed as enzyme solution (Eguchi *et al.* 1972). To avoid contamination the undigested food was removed from the gut before homogenization.

The activity of alkaline phosphatase in the midgut of healthy and diseased worms was determined in King Armstrong units (KA)/100 ml (Valey *et al.* 1980) by the following formula:

$$\text{Alkaline phosphatase activity in KA units} = \frac{\text{O.D.Test} - \text{O. D. Control}}{\text{O. D. Std.} - \text{O. D. Blank}} \times 10$$

Observations

In HM race the activity of alkaline phosphatase in the midgut of 3–day–old, 3rd instar healthy worms was 13.5 KA/100 ml and the pH was 9.8. The activity of alkaline phosphatase and pH both were decreased to 12.80 KA/100 ml and 9.3 (pH) respectively in the worms of the same age which were fed on the infected leaves. The alkaline phosphatase activity in the 4th instar healthy worms increased to 123.00 KA/100 ml with a highly alkaline pH (10.1). On the other hand, in the infected 4th instar worms, the alkaline phosphatase activity was significantly low (79.00 KA/100 ml) and pH was slightly acidic *i.e.*, 6.4. In 5th instar healthy worms, the alkaline phosphatase activity was 248.6 KA/100 ml and pH was 10.2 while in the diseased worms, the alkaline phosphatase activity decreased to 160.50 KA/100 ml with acidic (pH 4.5) gut, (Graph-1).

In the midgut of 3rd instar healthy worms of HS_6 race, the alkaline phosphatase conc was 32.66 KA/100 ml and the pH was 9. 7. The infected worms do not show any significant decrease in the alkaline phosphatase activity since it was 32.20 KA/100 ml and pH of the gut was 9. 6. In 4th instar healthy worms the activity was 152.27 KA/100 ml and pH was 10.2 which was significantly decreased in infected worms to 106.81 KA/100 ml and pH slightly acidic (6. 2). The alkaline phosphatase activity in the 5th instar healthy worms was 187.60 KA/100 ml with pH 10.2, which decreased significantly to 65.2 KA/100 ml and 3.8 respectively.

The alkaline phosphatase activity in 3rd instar healthy worms of Nistari race was 149.04 KA/100 ml and pH was 10.1 which decreased to 95.23 KA/100 ml and 9.1 (pH) in the infected larvae. In the 4th instar healthy worms enzyme activity was 161.00 KA/100 ml and pH was 10.3 which decreased to 118.00 KA/100 ml and pH

was 6.2. The enzyme activity in the fifth instar healthy worms was 292.00 KA/100 ml and pH was 10.4. The alkaline phosphatase activity decreased to 161.00 KA/100 ml and gut become highly acidic *i.e.*, 3.2.

The above studies in three different races of *B. mori* indicate that infection (synergic) of bacteria has affected the secretion of alkaline phosphatase in the midgut in different stages of development. This decrease in the activity of alkaline phosphatase is directly related with the gradual appearance of disease and development of acidic gut. The histological studies (unpublished data) also indicate that bacterial infection damages the columnar epithelium and goblet cells of the midgut, therefore, the secretory activity is greatly affected.

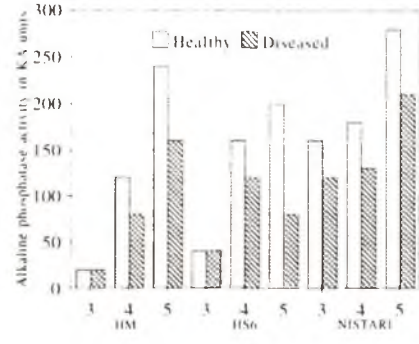

Fig. 1 Graph showing the levels of alkaline phosphatase activity in three difference races of *B. mori*

Discussion

The nature of midgut alkaline phosphatase was reported by Eguchi *et al.* 1972; Azuma and Eguchi, 1989; Takeda *et al.* 1990; Sujuki, Azuma and Yashimura, 1991; Azuma *et al.* 1991. These workers have established the presence of two alkaline phosphatase isozymes *i.e.*, membrane bound (M-ALP) and soluble (S-ALP) forms in the midgut of the silkworm larvae. Eguchi *et al.* (1990) illustrated the relationship between pH and enzyme activity. They noted that the optimum pH (10.9) for M-ALP and 9.8 for S-ALP. However, Eguchi, Sawaki and Suzuki (1972) noted the optimum activity of alkaline phosphatase in the digestive fluid of *B. Mori* at pH 11.00.

Azuma and Eguchi (1989) demonstrated clearly that *B. mori* ALP isozyme have their discrete localization in midgut epithelial cells. Their distinct nature has been determined by the cellular approach which provided further supporting evidence. The midgut epithelium of *B. mori* consists of mainly columnar epithelium and goblet cells (Akai, 1969; Dow, 1986). The former are responsible for the digestion and absorption of food stuff and synthesis of many digestive enzymes including secretory proteinases (Kariyama and Eguchi, 1985) and the latter are involved in osmotic and ionic regulation between haemocoel and gut lumen (Harvey *et al.* 1983).

In the present study it has been observed that the pH of midgut of healthy worms is highly alkaline (pH varies from 9.1–10.4) in different stages of development. Infection of bacteria reduces the pH as well as the concentration of alkaline phosphatase. However, in the 3rd instar, when the worms have started the infection, the pH was alkaline. The 4th instar worms have shown the symptoms of flacherie disease and the pH of midgut in such cases was acidic (the pH varies 6.2–6.4). The midgut become highly acidic in the 5th instar flacherie infected worm (3.2–4.5) of different races.

In the flacherie infected worms, the concentration of alkaline phosphatase decreased significantly from that in the normal worms. Histological studies indicate

that the midgut epithelium is highly damaged. The goblet cells show necrosis, therefore the secretory activity is also affected. Hence the conc. of alkaline phosphatase decreased to a very low level and worms died by "acid digestion" (Pringle, 1984). Therefore, it is concluded that it is the alkaline phosphatase secretion of goblet cells, which keep the gut alkaline and produces several enzymes which help in the digestion of food (Kuryama and Eguchi, 1985). The damage caused by bacteria affects the goblet cells and the columnar epithelial cells and therefore, secretion of alkaline phosphatase drop down significantly to lead acidic gut and therefore, worms stop feeding and ultimately die due to metabolic disturbances.

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References

Akai, H. (1969) Ultrastructural localization of phosphatases in the midgut of silkworm, *B. mori*. J. Insect Physiol., **15**, 1623–1628.

Azuma, M. and M. Eguchi (1989) Discrete Localization of distinct alkaline phosphatase isozyme in the cell surface of silkworm midgut epithelium. J. Exp. Zool., **251**, 108–112.

Dow, J. A. T. (1984) Extremely high pH in biological system: A model for carbonate transport. Am. J. Physiol., **246**, R633–R635.

Dow, J. A. T. (1986) Insect midgut function. Adv. Insect Physiol., **19**, 187–328.

Eguchi, M. M. Azuma, H. Yamamoto and S Takeda (19990) Genetically defined membrane–bond and soluble alkaline phosphatase of the silkworm: Their discrete localization and properties. Isozymes: Structure, function and use in Biology and Medicine. P Wily–Liss, Inc. 267–287.

Eguchi, M. and Iwamoto, (1975) Changes in protease, esterase and phosphatase in the alimentary canal of the silkworm during metamorphosis. Insect Biochem., **5**, 495–507.

Eguchi, M., M. Sawaki and Y. Suzuki (1972) Multiple forms of midgut alkaline phosphatase in the silkworm: New band formation and the relationship between the midgut and digestive fluid enzymes. Insect. Biochem., **2**, 297–304.

Eguchi, M., Sawaki and Y. Suzuki (1972) Multiple forms of midgut alkaline phosphatase in the silkworm: Separation and comparison of two isozymes. Insect Biochem., **2**, 167–174.

Harvey, W. R., M. Cioffi, J. A. T. Dow and M. G. Wolfersberger (1983). Potassium ions transport ATPase in insect epithelia. J. Exp. Biol., **106**, 91–117.

Horie, Y. (1958) Physiological studies on the alimentary canal of the silkworm *B. mori*. 1. Alkaline phosphatase of the midgut. Bull. Seric. Exp. Sta., **15**, 275–292.

Kuriyama, K. and M. Eguchi (1985) Conversion of the molecular farm by alkaline treatment of gut protease from the silkworm, *B. mori*. Comp. Biochem. Physiol, **82B**, 575–529.

Nakamura, T. (1940) The phosphorus metabolism during the growth of the animal. The behaviour of various phosphatase and phosphoric acid compounds of *B. mori* L. during growth. Mitt Med Akad Mioto **28**, 335–416.

Pringle, A. J. (1984) Report on the diseases of silkworms in India. International Books and periodicals supply service. 24 B/5, Deshbandhu Gupta Road, Karol Bagh, New Delhi, 65–75.

Sridhara, S. and J. V. Bhat (1963) Alkaline and acid phosphatase of the silkworm. *B. mori* L. J. Insect Physiol., **9**, 693–701.

Sugai, E. (1957) Alkaline phosphatase in the midgut of the silkworm larva, *B. mori*. J. Seri. Sci. Jpn., **26**, 35–39.

Suzuki, T., M. Azuma, T. Yoshimura and M. Eguchi (1991) Distribution, Synthesis and changes of alkaline protease activity in the larval midgut of the silkworm, *B. mori*. J. Seric. Sci. Jpn. **60**(5), 337–345.

Takeda, S., M. Azuma and M. Eguchi, (1990) Alkaline phosphatase isosymes of the silkworm midgut: Polymorphism in the enzyme activity, antigen and electrophoretogram. J. Seri. Sci. Jpn., **59**(2), 127–134.

Varley, H., A. H. Gownlock and M. Be. (1980) Practical clinical Biochemistry. William Heinemann Medical Books Ltd. 23 Bedford Square. London, **1**, 897–899.

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Effect of Methoprene and Diflubenzuron on Water, Lipid, Protein and Chitin Content of *Dicladispa armigera* (Coleoptera: Chrysomelidae)

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Abstract: In the methoprene and difulbenzuron–treated 0–day old fourth (last) instar larvae of the rice hispa, *Dicladispa armigera* (Olivier), water content increased but lipid and protein content decreased over age. However, reduction in water, lipid and protein content was evident in similarly treated 0–day old pupae and o–day old adults. Thus chitin deposition in adults was drastically affected by these regulators, diflubenzuron being more effective in comparison with that of the methoprene.

Keywords: *Dicladispa armigera*, methoprene, diflubenzuron, insect growth regulators, lipid reserves, protein content.

Insect cuticle is composed of chitin and protein; chitin forms the structural framework around which protein molecules arrange themselves (Grosscurt, 1978). Status of these biochemicals changes during growth and development as their percentages in the body of insects are dependent upon the rate of synthesis (Grosscurt, 1978, Vincent, 1978).

Exogenous application of growth hormones like methoprene and diflubenzuron can disrupt biochemical and physiological processes of insects resulting in abnormal growth and development (Retnakaran *et al.* 1985). In a review, Retnakaran *et al.* (1985) described various biochemical effects of methoprene, a juvenile hormone analogue and diflubenzuron, a chitin synthesis inhibitor. It is seen that studies showing the effect of these compounds on water, lipid, protein and chitin contents are scanty (Salama *et al.* 1976; Mitlin *et al.* 1977). However morphogenetic abnormalities (Kramer *et al.* 1989) and reproductive anomalies (Jacob, 1989) as caused by hydroprene and methoprene were already reported. The present study was undertaken to assess the effects of methoprene and diflubenzuron on the water, lipid, protein and chitin content in different stages of the rice hispa, *Dicladispa armigera* (Olivier) (Coleoptera: Chrysomelidae), a serious pest of rice (Hazarika and Dutta, 1991; Puzari and Hazarika, 1992).

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Materials and Methods

Insects

For water, lipid and protein estimation 12 hours post moult larvae, pupae, and 0–day old adults were treated with 1 ppm methoprene (62.5% RS. Altosid 5 E, Zeecon, Palo Alto, California, USA) and with 1000 ppm diflubenzuron (Dimilin 25 WP, Duphor, BV Amsterdam, Holland). However, for chitin estimation, 6 hr old adults were treated with these regulators.

Water content

By following Lee's (1961) technique, we estimated total body water of the untreated and treated larvae, pupae, and adults at 0, 24 and 48 hours of post treatment. Results were expressed in percentages of fresh body weight as in Bardolodi and Hazarika (1992).

Lipid estimation

Total lipids were extracted from 0.5 g untreated and treated fresh larvae, pupae, and adults (0, 24, and 48 hours of post treatment) by the method of Folch *et al.* (1957) and expressed in percentages of body weight as in Bardoloi and Hazarika (1992).

Protein estimation

Soluble proteins of the larvae, pupae and adults were estimated using bovine serum albumin as the standard (Lowry *et al.* 1951). Data were expressed as per cent dry weight of tissues. All these data were subjected to complete Randomized Block Design of Analysis of variance.

Estimation of chitin

Elytra were dissected out after every 24 hours following treatment for five days and boiled in 30% KOH for 15 minutes. They were subsequently washed 6 times with distilled water, twice with 96% alcohol and twice with ether. The elytra were weighed after oven drying at 100°C. Elytra from the normal untreated adults served as the control. This methods was followed by Grosscurt (1978) for estimation of chitin in the elytra of *Leptinotarsa decemlineata* Say.

Results

Water content of the 0 hour old 4th instar larvae, pupae and newly emerged adults of rice hispa were 87.95, 69.97 and 7.23 per cent respectively. A gradual decrease of water content in relation to age was observed in larvae and pupae, whereas in adults it increased slowly in relation to age. Water content increased in methoprene and diflubenzuron treated larvae in comparison with the control; however, in pupae and adults, it decreased (Table 1).

Lipid content increased with increase of age in larvae whereas a reverse relationship was observed for pupae and adults. Larval, pupal and adult lipid contents were 3.69, 5.07 and 2.93 per cent respectively. However, methoprene and diflubenzuron reduced the lipid reserves of the larvae, pupae and adults (Table 2).

Normally protein contents of newly moulted 4th instar larvae, pupae and newly emerged adults of rice hispa were 33.82, 50.12 and 33.44 per cent, respectively. Table

Table 1
Effect of methoprene and diflubenzuron on mean water content (%) of larvae, pupae and adults of rice hispa

Time	Stage	Control	methoprene	diflubenzuron
0 hr.	larva	87.950	87.990	88.147
	pupa	69.970	69.795	69.897
	adult	72.390	72.343	72.363
	larva	78.787	86.280	85.583
24 hr.	pupa	67.340	66.697	66.097
	adult	74.167	70.747	70.127
	larva	74.130	82.170	81.440
48 hr.	pupa	66.577	63.490	63.443
	adult	75.337	71.337	71.107

CD 0.05 = 0.24 (Time, Stage and Treatment)

Table 2
Effect of methoprene and diflubenzuron on mean lipid content (%) of larvae, pupae and adults of rice hispa

Time	Stage	Control	methoprene	diflubenzuron
	larva	3.701	3.703	3.703
0 hr.	pupa	5.070	5.073	5.079
	adult	2.903	2.903	2.900
	larva	4.250	3.877	4.003
24 hr.	pupa	4.730	4.503	4.593
	adult	2.637	2.363	2.453
	larva	4.493	4.200	4.260
48 hr.	pupa	3.733	3.357	3.500
	adult	2.617	2.243	2.387

CD 0.05 = 0.02 (Time, Stage and Treatment)

3 shows that protein content increased over age in the larval stage whereas it declined over age in case of pupae and adults. As a result of insect growth regulator treatments, the protein deposits of the larvae, pupae and adults were reduced (Table 3).

Both methoprene and diflubenzuron affected severely the chitin synthesis of adult rice hispa. Fig. 1 shows that in the control beetles the dry weights of deproteinized elytra increased linearly to day 4 after eclosion; on and beyond day 5 it levelled off. Both methoprene and diflubenzuron affected drastically the weight of the deproteinized elytra, diflubenzuron being more effective in chitin reduction.

Discussion

Methoprene and diflubenzuron are insect growth regulators; biochemical effects of these on insects were reviewed by Retnakaranana *et al.* (1985). Diflubenzuron was found to increase lipid content in insects (Salama *et al.* 1976). We also observed reduction in lipid content of the larvae, pupae and adults of rice hispa as a result of methoprene and diflubenzuron treatment. However, reports of the effect of methoprene on lipid content of insects are not readily available.

Table 3
Effect of methoprene and diflubenzuron on mean protein content (%) of larvae, pupae and adults of rice hispa

Time	Stage	Control	methoprene	diflubenzuron
	larva	33.823	33.842	33.833
0 hr.	pupa	50.123	50.137	50.133
	adult	33.447	33.429	33.443
	larva	41.860	35.633	36.253
24 hr.	pupa	38.043	20.690	21.217
	adult	29.460	22.470	23.933
	larva	51.260	43.270	45.067
48 hr.	pupa	21.463	17.357	18.033
	adult	27.473	22.907	23.907

CD 0.05 = 0.04 (Time, Stage and Treatment)

Mitlin *et al.* (1977) observed that diflubenzuron did not inhibit protein synthesis in boll weevils. In contrast, there was a decrease in protein content of those larvae, pupae and adults of rice hispa which were treated with diflubenzuron.

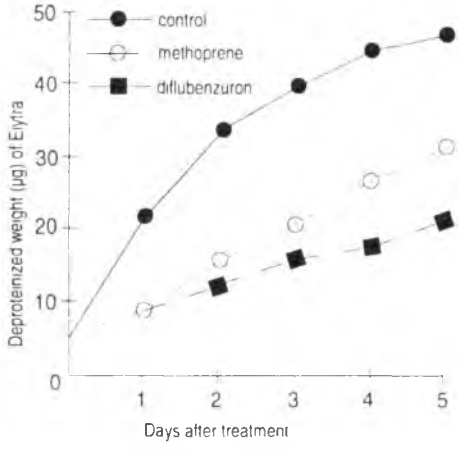

Fig. 1. Dry weight (mg) of deproteinized elytra of control, methoprene and diflubenzuron treated adults of *D. armigera* (mean of 50 right sided elytra per day per treatment).

Similarly, Tiwari (1989) reported reduction in haemolymph protein of *Diacrisia obliqua* (Walker) due to diflubenzuron treatment. Consequent upon inhibition of chitin synthesis by diflubenzuron, the protein deposition within the soft cuticle is affected which may contribute towards reduction in protein content in treated rice hispa. Scheller *et al.* (1978) were of the opinion that effects of methoprene on protein synthesis were rather confusing. It was reported that methoprene affected, biosynthesis of yolk protein (Scheller *et al.* 1978). We also observed a depression in protein content in methoprene treated pupae and adults but stimulation in larvae of rice hispa.

Increase in water content in methoprene and diflubenzuron treated larvae is difficult of explain. When tobacco caterpillars were administrated with JHA ($RO_{20-2600}$), Mathur and Srivastava (1987) observed an increase in water content. Diflubenzuron affects either the process of chitin synthesis (Ker, 1977; Rao and Mehrotra, 1987) or inhibits the enzyme, chitin synthetase (Vincent, 1978) as a result, the chitin content of treated adults of rice hispa was drastically reduced. Similar findings were also reported by Grosscurt (1978) in *L. decemlineata*. The cause of producing diflubenzuron–mimetic effects (*i.e.*, reduction in chitin content) by methoprene, a juvenile, hormone analogue on rice hispa adults

is unknown which requires further study.

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References

Bardoloi, S. and L. K. Hazarika (1992). Seasonal variation of body weight, lipid reserves, blood volumes and hemocyte populations of *Antheraea assama* (Lepidoptera, Saturniidae). *Environ. Entomol.* **21**: 1398–1403.

Folch, J. M. Lees and G. Stanley (1957). A simple method for the isolation and purification of total lipids from animal tissue. *J. Biol. Chem.* **226**: 497–509.

Grosscurt, A. C. (1978). Effect of diflubenzuron on mechanical penetrability, chitin formation and structure of the elytra of *Leptinotarsa decemlineatra*. *J. Insect. Physiol.* **24**: 827–831.

Hazarika, L. K. and B. C. Dutta (1991). Reaction of rice cultivars to rice hispa. *Int. Rice Res. Newsl.* **16**: 14–15.

Jacob, M. (1989). Influence of methoprene on the female reproductive system of *Oryctes rhinoceros* (Coleoptera: Scarabacidae). *Curr. Sci.* **58**(8): 469–471.

Ker, R. F. (1977). Investigation of locust cuticle using the insecticide diflubenzuron. *J. Insect Physiol.* **23**: 39–48.

Kramer, R. D., P. G. Koehler and R. S. Patterson (1989). Morphogenetic effect of hydroprene on German cockroach (Orthoptera: Blattellidae). *J. Econ. Entomol.* **82**(1): 163–170.

Lee, R. M. (1961). the variation of blood volume with age in the desert locust *Schistocerca gregaria* (F.) *J.* Insect Physiol. **6**: 36–51.

Lowry, G. H., N. J. Rosebrough, A. L. Farr and R. J. Randall (1951). Protein measurement with Folin–Phenol reagent. *J. Biol. Chem.* **193**: 267–275.

Mathur, N. M. and R. P. Srivastava (1987). Effect of JH analogues RO 20–3600 and FME on the water and fat contents of tobacco caterpillar *Spodoptera litura*. *Indian J. Appl. Ent.* **1**: 50–54.

Mitlin, N., Wiygul, G. and Haynes, J. W. (1977). Inhibition of DNA synthesis in boll weevils (*Antonomus grandis* Boheman) sterilized by Dimilin. *Pestic. Biochem. Physiol.* **7**: 559–563.

Puzari, K. C. and L. K. Hazarika (1992). Entomogenous fungi from North East India. *Indian Phytopath.* **45**: 35–38.

Salama, H. S., Z. A. Motagally and U. Skatulla (1976). On the mode of action of Dimilin as a moulting inhibitor in some lepidopterous insects. Z. Ang. Ent. **80**: 396–407.

Scheller, K., P. Karbon and D. Bodenstein (1978). Effects of ecdysterone and the juvenile hormone analogue methaprene on protein RNA and DNA synthesis in wing discs of *Calliphora vincta*. Z. Natur. **33C**: 253–260.

Rao, P. J. and K. N. Mehrotra (1987). Effect of diflubenzuron on chitin deposition in the wings of *Schistocerca gregaria* Forskel. Indian J. Ent. **49**: 76–80.

Retnakaran, A.; J. Granett and T. Ennis (1985). Insect growth regulators. In *Comprehensive Insect Physiology, Biochemistry and pharmacology* (Edited by Kerkut, G. A. and L. I. Gilbert). **12**: 529–601. Pergamon Press, New York.

Tiwari, L. D. (1989). Effect of diflubenzuron (Dimilin) treatment on the haemolymph proteins of *Diacrisia obliqua* (Walker). *Indian J. Ent.* **51**: 163–166.

Vincent, J. F. V. (1978). Cuticle under attack. Nature **273**: 339–340.

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Temperature–Dependent Development, Adult Longevity, Fecundity and Feeding Potential of two Coccinellid Predators under Laboratory Conditions

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Abstract: Laboratory studies were carried out at the Department of Entomology, Faculty of Agriculture, Annamalai University to determine the effect of temperature regime on the growth and development, adult longevity of the two commonly occurring coccinellids viz., *Coccinella transversalis* Fab. and *Menochilus sexmaculatus* Fab. at varied temperature levels like 18°, 24°, 30° and 36°C, fecundity at 20° and 30°C and feeding potential at 20°, 25°, 26°, 27°, 29°, 34°, 39° and 40°C. The test insect used was *Aphis gossypii* G. on brinjal. The increase in temperature from 18° to 36°C resulted faster development of the predators by reducing the duration of egg, grub and pupal stages at higher temperatures. The adult longevity was found to be maximum at 24° than at other tested temperatures like 18 or 30 or 36°C. Among the adults the females lived longer and produced more eggs at 30°C than at 20°C. Prey consumption by the grubs and adults of both the tested coccinellids was found to be maximum at 29°C level compared to other temperature regimes like 25°, 26°, 27°, 34° and 39°C.

Keywords: Coccinellid, Aphid, fecundity, feeding.

Introduction

The speed of development and activity of coccinellids are regulated by ambient temperature in common with all other insects. Such studies conducted on developmental requirements of beneficial insects like coccinellids contribute to the efficiency of mass rearing and providing a quantitative basis for predicting development, seasonal growth, activity and they increase our ability to use beneficial species in IPM programmes (Hodek, 1973). The responses of coccinellids to temperature may also provide some evidence to aid in the evaluation of relative competitiveness and adaptability to local temperature (Frazer and McGregor, 1992). However, the thermal requirements of coccinellids are poorly known. Hence, this paper examines the effect of varied temperature levels on growth and development, adult longevity, fecundity and feeding potential of two commonly encountered aphidophagous coccinellids of this region.

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Materials and Methods

To determine the most effective temperature for development of the two coccinellid predators namely *Coccinella transversalis* Fab. and *Menochilus sexmaculatus* Fab., petridishes containing egg batches were kept in incubators at different temperature regimes, viz., 18°, 24°, 30°C and 36°C. Each treatment was replicated three times. The incubation period was determined in terms of days.

The newly emerged grubs were taken in glass vials of 5 cm length and covered with muslin cloth. Brinjal leaf containing about 100 aphids of all ages was introduced into the vials and then closed. They were then kept at various temperatures as done earlier and the treatment was replicated three times. The time taken for the first moulting and the time interval between 2nd, 3rd and 4th moulting were recorded. The prey aphids were added to the vials as and when required. As the grubs transformed into pupae the pupal period under the above temperatures was determined. The longevity of three male and three female predators in each temperature was also determined.

To study the influence of temperature on the fecundity of the predators, emerged females collected from the stock culture were kept individually with one male for copulation for 24 hrs. Later, the females were separated, placed individually in petridishes containing 100 aphids at two temperature levels viz., 20° and 30°C. The total number of eggs laid by each female were counted at every day and the females were removed to fresh dishes containing 100 prey aphids on brinjal leaf. The experiment was replicated ten times and continued until all the females were dead.

To find the effect of temperature on the feeding potential of the above two predators, newly emerged grubs were kept in individual glass vials containing 100 aphids of all ages and closed with muslin cloth. The vials were kept in incubators set at different temperatures viz., 10, 20, 25, 26, 27, 29, 34 and 40°C. Each treatment was replicated three times. After 24 hrs the total number of aphids consumed by the individual grub was determined. the second, third, fourth instar grubs and male and female adults were also experimented similarly.

The uniformity of mean development duration for different growth stages, fecundity and feeding potential at various temperature regimes was tested using analysis of variance two way classification. Multiple comparisons of the data were also made using DMRT (Draper and Smith, 1966).

Results and Discussion

The rate of development of different stages of *C. transversalis* and *M. sexmaculatus* was found to be significantly affected by temperature and significant influence of various temperature on the developmental stages of the predators were also obtained (Table 1). Both the predators took maximum time (30.01 and 18.14 days) for the full development at the minimum temperature of 18°C as against the minimum period (14.7 and 9.8 days) at the maximum temperature 36°C that was on par with values for 30°C. Other tested temperature such as 24° and 30°C show intermediate development periods for both the predators. Correspondingly, developmental periods for egg, larval instars and other stages tend to get reduced as the temperature went up. Both the insects behaved similarly in this respect. Similar kind of susceptability was observed in *C. septempunctata* (Hodek, 1958. Sethi and Atwal, 1964), *M. sexmaculatus*

Table 1: Influence of various temperatures on the development of *C. transversalis* and *M. sexmaculatus* (in days)

Temperature	Egg	Ist	IInd	IIIrd	IVth	Pupa	Total life period
18°C	7.23	3.20	3.56	3.86	4.06	9.10	30.01a
	(2.45)	(2.63)	(2.60)	(2.86)	(2.60)	(5.00)	(18.14A)
24°C	4.00	2.03	2.76	3.60	3.70	6.83	22.92b
	(1.71)	(1.76)	(1.90)	(1.96)	(1.86)	(3.90)	(13.19B)
30°C	2.83	1.10	2.00	2.86	2.70	5.23	16.72c
	(1.48)	(1.58)	(1.55)	(1.50)	(1.51)	(2.76)	(10.38C)
36°C	2.26	1.13	1.23	2.30	2.26	5.56	
	(1.43)	(1.50)	(1.40)	(1.60)	(1.40)	(2.45)	(14.74C)
Mean	4.08	1.86	2.39	3.15	3.18	6.68	
	(1.77)	(1.87)	(1.86)	(1.98)	(1.84)	(8.52)	

S. E. = 0.25865 (*C. transversalis*): S. E. = 0.2555 (*M. sexmaculatus*)
Values in parentheses are for *M. sexmaculatus*
Means followed by the same letter are not significantly different (P = 0.05) by DMRT.

Table 2: Influence of temperatures on adult longevity of *C. transversalis* and *M. sexmaculatus* (in days) (Mean of three observations)

Predator	Sex	Temperature levels				Mean
		18°C	24°C	30°	36°	
C. transversalis	Male	22.33	25.66	22.33	19.96	22.57 B
M. sexmaculatus	Male	16.33	16.40	13.66	11.33	14.43 b
C. transversalis	Female	24.00	29.00	25.66	18.30	24.24 A
M. sexmaculatus	Female	20.66	20.66	19.50	17.33	19.53 a
C. transversalis	Mean	23.16 B	27.33 A	24.00 B	18.18 C	
M. sexmaculatus	Mean	18.50 a	18.53 a	16.58 a	14.30 a	

S. E. = 0.4139 (*C. transversalis*): S. E. = 0.7793 (*M. sexmaculatus*)
Means followed by the same letter are not significantly different (P = 0.05) by DMRT.

(Kawauchi, 1979) and *C. repanda* (Saharia, 1981).

The data on longevity for both the predators under different temperature showed significant variation. In the case of *C.* transversalis adults, among the tested temperatures the life span was maximum (27.33 days) at 24° than at 18°, 30° and 36°C. The female predator lived longer (24.24 days) than male (22.07 days) at all levels of temperature (Table 2).

In *M. sexmaculatus* no significant difference was noted in adult life span at various temperatures (Table 2). The mean adult longevity was 18.53 days at 24° than at 18°, 30° and 36°C.

Although the development was enhanced at higher temperatures, the adults, lived longer at medium temperatures, thus indicating that the adults would automatically migrate to other places where optimum temperature exists. Among the adults, the female predator lived longer possibly spending the time well in selecting a suitable

Table 3: Fecundity of two conccinellids at two different temperature levels (Mean of 10 observations)

Temperature	Name of the predator	No. of females	Agerage number of eggs laid/female	Range	Average number of eggs laid/female/day
20°C	*C. transversalis*	10	422	20–63	27.2
	M. sexmaculatus	10	182	12–54	18.5
30°C	*C. transversalis*	10	585	25–70	34.1
	M. sexmaculatus	10	210	18–66	21.3

site for egg laying. Extended longevity of females had been earlier observed by Sethi and Atwal (1964) in *C. septempunctata*, Rajamohan and Jayaraj (1974) in *M. sexmaculatus* and by Saharia (1981) in *C. repanda*.

Results obtained on the egg laying capacity of the two coccinellids revealed that more number of eggs were laid at 30° than at 20°C (Table 3). Increased egg laying at high temperatures has also been observed in *C. septempunctata* (Sethi and Atwal, 1964), *C. repanda* (Anderson and Hales, 1986) and in *M. sexmaculatus* (Alikhan and Yousuf, 1986).

Such differences in egg laying, development and longevity among the ladybirds at varied temperature levels have been attrived to the fact that at higher temperature, the metabolic rate increases resulting in increased activity and the extra energy is expanded on growth (Ives, 1981). At very high temperatures it becomes less active more flighty and tends to migrate from such places (Anderson and Hales, 1986).

The data on the number of aphids consumed by the predators in 24 hrs time at different temperature showed significant difference in the mean number of aphids consumed. In the case of *C. transversalis* adults (male and female) and grub instars consumed the maximum number of aphids at 29°C. The mean level of feeding by all stages of grubs and adults at other temperature levels remained statistically on par. The mean feeding rate was minimum at 39°C (35.88) and no feeding was seen at 40°C in *C. transversalis*. Among the sexes the female predator consumed the maximum number of aphids at all temperature levels and the feeding by IInd, IIIrd, and IVth instar grubs were on par statistically. In *M. sexmaculatus* also the consumption by all instars and adults was maximum at 29°C followed by 27°, 26°, 34°, 39°, 25° and 20°C and no feeding was seen at 40°C. Between the two sexes the females consumed more aphids (51.2) than the male (41.23), IIIrd instar grub (32.28), IV instar grub (27.71), IInd instar grub (24.52) and Ist instar grub (20.52) (Table 4).

The feeding rate of the predators is another important aspect that influences the predator potential of the beetles. In the present studies it was evident that the prey consumption by grubs and adults was enhanced as the temperatures increased from 20°C. Although feeding was observed at high temperatures, maximum feeding was evident at 29°C in both the predators. This might be the optimum temperature for feeding under laboratory conditions. Verma and Chowdhuri (1977) observed that *C. septempunctata* beetles on an average devoured 42, 49 and 46 aphids at 22.5°C,

Table 4: Effect of temperature on the feeding rates of *C. transversalis* (I) and *M. sexmaculatus* (II) in numbers

Stage of predator		Temperature levels							Mean
		20°C	25°C	26°C	27°C	29°C	34°C	39°C	40°C	
Ist stage	I	22.66	27.00	30.30	32.66	32.99	25.33	17.99	0.00	22.00 D
grub	II	18.33	19.33	22.00	22.99	24.66	20.33	16.00	0.00	20.52 e
IInd stage	I	29.00	33.33	43.00	48.33	45.00	34.66	28.66	0.00	37.42 C
grub	II	21.66	20.33	25.66	27.00	27.99	25.99	22.99	0.00	24.52 de
IIIrd stage	I	37.00	41.99	46.66	47.66	51.33	45.66	39.00	0.00	44.19 C
grub	II	25.33	29.00	32.33	37.99	40.33	32.00	29.00	0.00	32.28 c
IVth stage	I	45.66	50.33	40.99	37.99	41.33	39.00	32.66	0.00	41.14 C
	II	24.33	22.66	30.66	33.66	32.66	26.33	23.66	0.00	27.72 cd
Male	I	55.00	55.99	62.66	58.00	61.66	54.66	44.66	0.00	56.09 B
	II	30.33	35.99	42.66	50.00	50.33	41.99	37.33	0.00	41.23 b
Female	I	62.00	65.00	62.33	64.00	70.99	64.33	52.33	0.00	63.00 A
	II	39.33	45.99	56.99	57.33a	59.61	54.00	45.66	0.00	51.28 a
Mean	I	41.88 B	45.61 AB	46.66 AB	48.11 AB	50.55 A	43.94 AB	35.88 C	0.00	
	II	26.55 e	28.88 de	35.05 abcd	38.16 ab	39.27 a	33.44 bcd	29.11 cde	0.00	

S. E. = 2.6607 (*C. transversalis*): S. E. = 1.9347 (*M. sexmaculatus*)
Means followed by the same letter are not significantly different (P = 0.05) by DMRT.
Means were calculated based on the values of 20°C and 39°C alone.

26.0 and 24.4°C respectively. Same phenomenon was observed in another predator *Harmonia dinaidaba* Fab. (Chakrabarti, *et al.* 1988), but in some coccinellids like *A. bipunctata* increased feeding of aphids was noted at low temperature than at high temperature (Gurney and Hussey, 1970).

References

Alikhan, M. A. and M. Yousuf. 1986. Temperature and food requirements of *Chilomenes sexmaculata* (Coleoptera: Coccinellidae) *Environ. Entomol.*, **15**(4): 800–802.

Anderson, J. M. E. and D. F. Hales. 1986. Coccinellid repanda Diapaus Hodek, I (ed) Ecology of Aphidophage, Academia, Prague, and W. Junk, Dordrecht, pp. 233–238.

Chakrabarti, S., D. Ghosh and N. Debnatha. 1988. Developmental rate and larval voracity in *Harmonia dimidiata* (Col.: Coccinellidae), a predator of *Eriosoma lanigerum* (Hom.: Aphididae) in Western Himalaya. *Acta Entomol. Bohemoslov.* **85**(5): 336–339.

Draper, N. R. and H. Smith. 1966. Applied Regression Analysis. John Wily and Sons, New York.

Frazer, B. D. and R. R. McGragor. 1992. Temperature Dependent survival and hatching rate of eggs of seven species of coccinellide. *Can. Ent.* **124**: 305–312.

Gurney, B. and N. W. Hussey. 1970. Evaluation of some coccinellid species for the biological control of aphids in protected cropping. *Ann. Appl. Biol.*, **65**: 451–458.

Hodek, I. 1958. Influence of temperature, relative humidity and photoperiodicity on the speed of development of *Coccinella septempunctata* L. *Cas. Cs. Spol. Ent.*, **55**: 121–141.

Hodek, I. 1973. Biology of Coccinellidae. Academia, Prague and W. Junk, the Hague, p. 260.

Ives, P. M. 1981. Coccinellids (Coleoptera) and Aphids (Homoptera): Feeding and egg production of two species of coccinellids in the laboratory. *Can. Ent.*, **113**(11): 999–1005.

Kawauchi, S. 1979. Effects of temperatures on the aphidophagous Coccinellids. *Kurume Univ., J.* **28**(1): 47–51.

Rajamohan, N. and S. Jayaraj. 1974. Growth and Development of the coccinellid *Menochilus sexmaculatus* Fabricius on four species of aphids, *Madras Agric. J.*, **61**(5): 118–122.

Saharia, D. 1981. Biology of *Coccinella repanda* Thunb. an important predator of mustard aphid *Lipaphis erysimi* (Kltb) in Assam. *J. Res. Assam, agric. Univ.*, **2**(1): 66–73.

Sethi, S. L. and A. S. Atwal. 1964. Influence of temperature and humidity on the development of different stages of lady bird beetle, *Coccinella septempunctata* (Coleoptera: Coccinellidae). *Indian J. agric. Sci.*, **34**(3): 166–171.

Verma, K. L. and A. N. Chowdhuri. 1977. Predation on peach curl aphid *Brachycaudus helichrysi* Kaltenbach by Coccinella septempunctata Linnaeus. *Indian J. Ent.* **37**(3): 315–316.

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Cardiotoxicity of the Grasshopper, *Poecilocerus pictus* Defensive Secretion in the Garden Lizard, *Calotes nemoricola*

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Abstract: The grasshopper, *Poecilocerus pictus* ejects a defensive fluid as an escape measure against the attack of predators. Injection of the defensive fluid of grasshopper into the predatory lizard, *Calotes nemoricola* produced irregular R–waves and bradycardia. It appears that the defensive fluid of the *P. pictus* contains cardenolides which the animals obtain through their food plants (*Calotropis* sp. Asclepiadaceae).

Keywords: Defensive fluid, grasshopper, garden lizard, cardiotoxicity, bradycardia.

Introduction

Many arthropods produce secretions which are used for defense and offense against other arthropods or predatory animals. These defensive secretions, in general, are repellent in nature and produce number of toxic effects in the predatory animals (Eisner 1966; 1968 Tshinkel, 1975; Blum, 1978). In recent years, research efforts in this area of insect toxicology have been greatly intensified and the chemical composition of many defensive secretions, and the mechanisms of discharge are now known (Eisner, 1958; von Euw *et al.* 1967; Tshinkel, 1969; Rothshild and Kellet, 1972, Blum 1981). However, similar studies on the insects of India are rather scanty despite the presence of rich population of a wide range of insect species. Even the abundantly available insects like the grasshopper *Poecilocerus pictus*, which feeds exclusively on *Calotropis sp.* (Asclepiadaceae) plants and possesses a fascinating defensive chemical discharge mechanism was not paid much attention. Therefore, the present study was undertaken to evaluate the cardiotoxicity of the defensive secretion from the grasshopper, *Poecilocerus pictus* in the predatory lizard, *Calotes nemoricola.*

Materials and Methods

The defensive fluid of the grasshopper *P. pictus* was collected into a glass vial by mechanically stimulating the animal. Pinching with a fine–tipped forceps in the thoracic region was found to be an adequate stimulus for eliciting the defensive discharge.

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The defensive fluid was diluted with physiological saline and injected intramuscularly into the thigh muscle of the garden lizard, *C. nemoricola*. A lethal dose of the fluid that can kill 50% of the injected lizards within 24h ($LD_{50(24h)}$) was determined (Finney, 1971) and 1/3rd of the lethal dose was considered as sublethal dose (0.082μl/gm. body weight). Electrocardiograms of both control and experimental animals were taken using the portable ECG recorder (BPL–cardiart 108T/MK-IV) at different time intervals from the surface of the body on the ventral side above the heart region, and directly from the surface of the heart in the dissected animals.

Results and Discussion

The electrocardiograms of the lizards, *C. nemoricola*, injected with lethal and sublethal doses of defensive fluid of *P. pictus* showed significant changes in both the frequency of heartbeat as well as the wave form (Fig. 1).

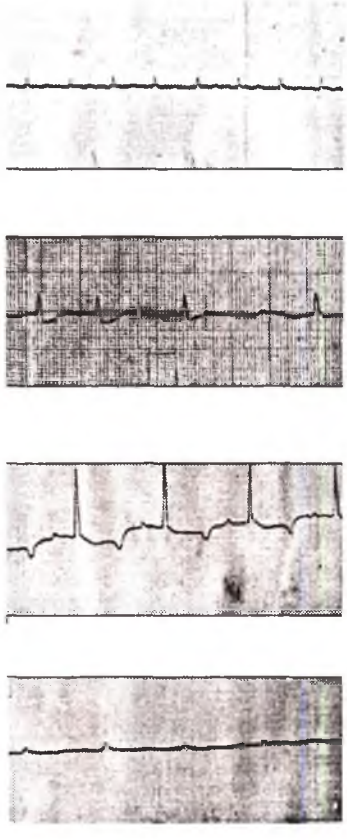

Fig. 1. Effects of the defensive secretion of *P. pictus* on electrocardiogram of the lizard, *C. nemoricola*. (a) control (b) ST segment changes and irregular R-waves (c) T wave inversions (d) bradycardia

The mean (±SD) heart rate in the control lizards was 125±5 beats/min. Following the administration of a lethal dose of defensive fluid, the lizards exhibited bradycardia (mean heart rate: 60±4/min.) within one hour after treatment. The sublethal doses took much longer time (12h) to produce similar bradycardia (72±4/min.). Unlike lethal doses, the complexity of cardiac changes was not severe with sublethal doses. The ST segment changes, T wave inversions and irregular R waves were more pronounced in the ECG records taken from the heart than the records made from the body surface. The reduction in the heartbeat of the defensive fluid treated animals, as revealed from the electrocardiogram records might be due to sinus bradycardia. Similar to the *P. pictus* defensive fluid, scorpion toxins were also reported to induce bradycardia in isolated heart preparations (Ismail *et al.* 1980). The changes observed in the lizards treated with *P. pictus* defensive fluid strongly suggest the presence of cardenolides in the defensive fluid. The presence of digitalis like cardenolides in the grasshopper, *Poekilocerus bufonius* reported by von Euw *et al.* (1967) strongly supports this possibility. Similar to the aposematic monarch butterfly which obtain protection from cardenolides present in their Asclepiadaceae food plants (*Reichstein et al.* 1968) the grasshopper *P. pictus* may also obtain cardenolides (calactin, calotropin etc.) into the defensive fluid through their Asclepiadaceae (Calotropis sp.) food plants.

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References

Blum, M. S. (1978) Biochemical Defenses of Insects. In: Biochemistry of Insects (Eds. M. Rockstein). Academic Press, New York. pp 465.

Blum, M. S. (1981) In: *Chemical Defenses of Arthropods*. Academic Press, New York. pp 562.

Eisner, T. (1958) The protective role of the spray mechanism of the bombardier beetle, *Brachynus ballistarius*. *J. Insect Physiol.*, **2:** 215.

Eisner, T. (1966) Beetles spray discourages predators. *Nat. Hist.*, **75(2)**: 42.

Eisner, T. (1968) Defensive spray of a plasmid insect. *Science.*, **148**: 966.

Finney, D. J. (1971) ' *Probit Analysis*'. 3rd edition, Cambridge University Press, London. pp 333.

Ismail, M., Ghazal, A. and El–Fakahnny, E. E. (1980) Cardiovascular effects of venom from the scorpion, *Buthus occitanus* Amoreux. *Toxicon.*, **18**: 32.

Reichstein, T., von Euw, J., Parsons, J. A. and Rothschild, M. (1968) Heart poisons in the monarch butterfly. *Science.*, **161**: 861.

Rothschild, M. and Kellet, D. N. (1972) Reactions of various predators to insects storing heart poisons (cardiac glycosides) in their tissues. *J. Entmol Ser.*, **A46**: 103.

Tschinkel. W. R. (1969) phenol and quinones from the defensive secretions of the tenebrionid beetle, *Zophobas rugipes*. *J. Insect Physiol.*, **15:** 191.

Tschinkel, W. R. (1975) A comparative study of the chemical defensive system of tenebrionid beefles. J Insect Physiol., **21:** 753.

von Euw. J., Fischelson. L., Parsons. J. A., Reichstein. T. and Rothschild, M. (1967) Caredenolides (heart poisons) in a grasshopper feeding on milkweeds. *Nature.*, **214**: 35.

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Cercal Sensory Regulation of Rhythmicity in Escape Behaviour of the Cockroach, *Periplaneta americana*

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Abstract: Rhythmicity in escape behaviour of the cockroach, *Periplaneta americana* was studied using normal and cercectomized animals against the attacks of diurnal predator lizard, *Calotes nemoricola* and nocturnal predator toad, *Bufo melanosticus*. Escape ability was more in normal animals than cercectomized animals. The number of attacks by predators and percent escapes of cockroaches was tested to suggest a rhythmic sensory input into the neural circuitry of the escape system in the cockroach and the existence of non–GI evasive turning and the extent of its contribution to the escape behaviour of cockroaches.

Keywords: Cerci, Rhythmicity, Cercectomy, Predator, Neural circuitry, Giant interneurons.

Introduction

Many orthopterous insects possess a pair of abdominal appendages, the cerci, which serve as highly sensitive mechanoreceptive organs that are involved in a variety of orientations in escape behaviour. The sensory neurons associated with filiform hair excite 7 bilateral pairs of Giant interneurons (Westin *et al.* 1977; Sekhar, 1990) which have been implicated in the control of the oriented evasive behaviour (Ritzmann and Camhi, 1978; Camhi and Tom, 1978; Comer and Camhi, 1984; Vardi and Camhi, 1982; Sekhar and Rajarami Reddy, 1988).

Circadian rhythms of activity in response of changing photoperiod have shown to play a major part in insect life (Beck, 1963). Rhythmcity in various physiological and behavioural activities of the cockroach was reported earlier by several investigators (Cloudsley–Thompson, 1953; Harker, 1960, 1964; Lipton and Sutherland, 1970; Rajarami Reddy *et al.* 1977; Vijayalakshmi *et al.* 1977). Farley and Case (1968) reported the role of sensory input in the generation of rhythmic behaviours. Saunder (1982) reported the rhythmic nature of the nerve impulses to the interactions between predator and prey.

Daily cycles of activity in the nervous system of insects have attracted attention because of the possible importance of these systems in the control of overt rhythm of physiology and behaviour. Therefore, the present study was aimed at investigating the

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rhythmicity in escape behaviour and the underlying neural circuitry in the cockroach, *P. americana.*

Materials and Methods

The cockroaches maintained in the laboratory were fed daily with rice and bread on a fixed feeding time schedule (Harker, 1974). Adult male cockroaches were selected and divided into three batches. The first batch served as controls while the animals in second and third batches had undergone cercectomy (unilateral and bilateral) respectively three days prior to experimentation. Natural predators of both nocturnal (Toad, *Bufo melanosticus*) and diurnal (lizard, *Calotes nemoricola*) nature were collected from nearby fields and maintained in cages and starved for 48 hours before experimentation. At the time of observation, both the predators and prey were released with minimum external disturbance. Normal and cercectomized animals were allowed to move at the entrance of the predator cages. In order to study the rhythmicity in the escape response, the cockroaches were tested against the attacks of the predators at four different time periods (viz. 00.00h, 06.00h, 12.00h and 18.00h) of 24h day. Data were subjected to statistical treatment.

Results

The escaping ability of cockroaches from attacks of predators was more in normal animals than cercectomized (unilateral or bilateral) at different time periods of 24h day (Table 1). However, the escape efficiency of normal animals showed a great variation during light hour period with 45.5% escapes at 18.00h followed by 40.0% at 06.00h and only 23.5% at 12.00h. Among the cercectomized, the unilaterally cercectomized animals showed more number of successful escapes than bilaterally cercectomized animals. Of the two predators, the diurnal predator exhibited more number of successful attacks than the nocturnal predator at all these three time periods (6.00h, 12.00h and 18.00h) in a 24h day. The diurnal predator made highly successful attacks on cockroaches at 12.00h with no significant difference between the normal and cercectomized (unilateral or bilateral) animals (Table 1). Nocturnal predator on the other hand, made more successful attacks on bilaterally cercectomized than unilaterally or normal animals at different dark hour periods (18.00h, 0.00h and 06.00h) of the 24h day. The percent escapes for cockroaches against the toads were more at 18.00h followed by 00.00h than 06.00h. The significance of results were tested using Mann-Whitney–U test.

Discussion

The results of the present study showed that the number of escapes made by the cockroach from the attacks of predators was more in normal animals than cercectomized (either unilateral or bilateral). These results are in agreement with earlier findings in cockroaches (Camhi, 1980; Camhi *et al.* 1978; Vardi and Camhi, 1982; Simpson *et al.* 1986), crickets (Edwards and Palka, 1974; Tobias and Murphy, 1978) and locusts (Boyon *et al.* 1986). Among the cercectomized cockroaches, the insects with both cerci ablated were more susceptible to capture by predators. The reduced escape efficiency in bilaterally cercectomized animals was due to the excessive damage and

Table 1: Escape efficiency of cockroach, *Periplaneta americana*, in response to diurnal and nocturnal predators during selected time periods of 24th day.

Predator	Time of Day (h)	Condition of prey (cockroach)	Number of strikes	Number of escapes	Percent escapes	Mann–Whitney U–test
Calotes	06.00	Normal	30	12	40	P<0.01 (1 vs 3)
nemoricola		unilaterally cercetomized	24	8	33.4	P<0.01 (2 vs 3)
		bilaterally cercectomized	19	5	26.72	P<0.01 (5 vs 2)
	12.00	Normal	34	8	23.50	P>0.05 (1 vs 3)
		unilaterally cercetomized	28	7	25.00	P<0.01 (2 vs 3)
		bilaterally cercectomized	23	5	21.7	P>0.05 (1 vs 2)
	18.00	Normal	33	15	45.5	P<0.01 (1 vs 3)
		unilaterally cercetomized	30	10	33.3	P<0.01 (2 vs 3)
		bilaterally cercectomized	24	5	20.8	P<0.05 (1 vs 2)
Bufo	18.00	Normal	41	25	60.97	P<0.01 (1 vs 3)
melanosticus		unilaterally cercetomized	36	14	38.89	P<0.01 (2 vs 3)
		bilaterally cercectomized	35	8	22.85	P<0.05 (1 vs 2)
	00.00	Normal	47	27	57.45	P<0.01 (1 vs 3)
		unilaterally cercetomized	41	16	39.02	P<0.01 (2 vs 3)
		bilaterally cercectomized	36	7	19.5	P<0.05 (1 vs 2)
	06.00	Normal	45	24	52.17	P<0.01 (1 vs 3)
		unilaterally cercetomized	37	10	27.02	P<0.01 (2 vs 3)
		bilaterally cercectomized	34	6	17.64	P<0.05 (1 vs 2)

$p<0.01 - 0.05$: Significant; $p>0.05$: Not significant.

degeneration of axons and terminals in the cercal mechanosensory GI–pathways. The results of the present study, partly published elsewhere (Sekhar and Rajarami Reddy, 1988), demonstrated a rhythmicity in escape behaviour of the cockroach *P. americana*. The percent escapes against the attack of predators was more during the dark hours than light hour period of 24h solar day, in tune with the nocturnal behaviour of the cockroach. The difference in the speed of the strike by diurnal and nocturnal predators and its influence on the percent escapes by a nocturnal prey (cockroach) at different hours of day is ruled out since the predators (both nocturnal and diurnal) tested for attacks on cockroaches at two common hours (06.00h and 18.00h) yielded similar results, the normal animals being more effective in escape than the unilaterally and

bilaterally deafferented. This difference may be due to a low rhythmicity predation efficiency of the predators. Because of this possibility, a diurnal predator was used for studying the escapes at 12.00h while a nocturnal predator attacked at 00.00h. Based on the prey–predator interactions, it was proposed that the differences in the escape efficiency of the cockroach during different time periods of 24h day was due to the differences in processing of sensory input in cercus–GI pathway. The fact that there was no significant difference in the escape efficiency of normal and cercectomized animals at 12.00h when the animals were inactive in their behaviour, supports the above possibility. Cockroaches clearly exhibited a difference in escape ability among normal and cercectomized individuals during dark hour period, the animals active phase of the 24h day.

The cercectomized, even bilaterally, still exhibited a reduced escape ability with a significant difference between unilateral and bilateral during dark hour period. This is probably because of non–cercal sensory input that can drive the turning behaviour in cockroaches. It has also been noted that some locomotor responses to wind survive complete removal of the cerci in the nymphal cockroaches (Vardi and Camhi, 1982). The wind triggered turning and running responses persist even with complete lesion of cercal to GI pathway at the abdominal level (Comer *et al.* 1988) suggesting a contribution of non–GI pathways for which the antenna may be one source of afferent input. The existence of non–GI evasive turning and its contribution to the escape behaviour of cockroaches may require further research on the system.

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References

Beck, D. S. (1963) Animal photoperiodism. Holt, Rinchart and Winston, INC, New York.

Boyon, G. S., S. Ashman and E. E. Ball (1986) Initiation and modulation of flight by a single giant interneuron in the cercal system of the locust. *Naturwissenschaften.*, **73:** 272.

Camhi, J. M. (1980) The escape system of the cockroach, *Sci. Amer.*, **242**, 158–172.

Camhi, J. M. and W. Tom (1978) The escape behaviour of the cockroach, *Periplaneta americana.* I. Turning responses to wind puffs, *J. Comp. Physiol.*, **128,** 203–212.

Camhi, J. M., W. Tom and S. Volman (1978) The escape behaviour of the cockroach, *Periplaneta americana.* II. Detection of natural predators by air displacement. *J. Comp. Physiol.*, **128,** 203–212.

Comer, C. M. and J. M. Camhi (1984) Behavioural compensation for altered cercal position in the cockroach, *J. Comp. Physiol.*, **155,** 31–38.

Comer, C. M., J. P. Dowd and G. T. Stubblefield (1988) Escape responses following elimination of the giant interneuron pathway in the cockroach, *Periplaneta americana. Brain Res.* **445,** 370–375.

Clodsley–Thompson, J. L. (1953) Studies on diurnal rhythms III. Photoperiodism in the cockroach, *Periplaneta americana L. Ann. Mag. Nat. Hist.*, **6,** 705–712.

Edwards, J. S. and J. Palka (1974) The cerci and abdominal giant fibres of the house cricket, *Acheta domesticus.* I. Anatomy and physiology of normal adults. *Proc. Royal Soc. Lond. B.*, **185,** 83–103.

Farley, R. D. and J. F. Case (1968) *J. Insect Physiol.*, **14,** 591.

Harker, J. E. (1960) The effect of perturbations in the environmental cycle on the diurnal rhythmic activity of *Periplaneta americana. L. J. Exp. Biol.*, **37,** 154–163.

Harker, J. E. (1964) The physiology of diurnal rhythms. *Cambridge Univ. Press.* London.

Lipton, G. R and D. J. Sutherland (1970) Circadian rhythmicity in the oviposition of the grasshopper, *Chorhippus curtipennis. J. Insect Physiol* **16,** 1677–1688.

Rajarami Reddy, G., T. Pavankumar, P. Muralimohan and K. Sasira Babu (1977) Circadian activity of adenosine triphosphatase in the nervous system of the cockroach, *Periplaneta americana*. *Curr. Sci.*, **46,** 493–495.

Ritzmann, R. E. and J. M. Camhi (1978) Excitation of leg motor neurons by giant interneurons in the cockroach, *Periplaneta americana*. *J. Exp. Physiol.*, **125,** 305–316.

Saunders, D. S. (1982) *Insect clocks*. Pergamon Press, Oxford.

Sekhar, V (1990) Physiological changes in the deafferented terminal ganglion of the cockroach, *Periplaneta americana*. Doctoral thesis, S. V. University, Tirupati, India.

Sekhar, V. and G. Rajarami Reddy (1988) Mechanosensory regulation of predator evasion behaviour in the cockroach, *Periplaneta americana* *Curr. Sci.*, **57,** 1141–1142.

Simpson, B. S., R. E. Ritzmann and A. J. Pollack (1983) A comparison of the escape behaviour of the cockroaches, *Blaberus craniifer* and *Periplaneta americana*. *J. Neurobiol.*, **17,** 405–419.

Sokal, R. R and J. F. Rohlf (1973) Introduction to biostatistics. W. H. Freeman and Co., Sanfrancisco.

Tobias, M. and R. K. Murphy (1979) The responses of cercal receptors and identified interneurons in the cricket, *Acheta domesticus* to air streams. *J. Comp. Physiol.*, **129,** 51–59.

Vardi, N. and J. M. Camhi (1982) Functional recovery from lesions in the escape system of the cockroach. II. Physiological recovery of the giant interneurons. *J. Comp. Physiol.*, **146,** 299–309.

Vijayalakshmi, S., P. Muralimohan and K. S. Babu (1977) Circadian rhythmicity in the nervous system of the cockroach, *Periplaneta americana*. *J. Insect Physiol.*, **23,** 195–202.

Westin, J., J. J. Langbarg and J. M. Camhi (1977) Responses of giant interneurons of the cockroach *Periplaneta americana* to wind puffs of different directions and velocities. *J. Comp. Physiol.*, **121,** 307–324.

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Studies on Incidence of Uzifly (*Exorista bombycis* Louis) Infestation on Silkworm (*Bombyx mori* L.) and Assessment of Cocoon Crop Loss in Murshidabad District (West Bengal, India)

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Abstract: Survey conducted in commercial sericultural areas of Murshidabad District of West Bengal from February 1991 to November 1992, which included 10 rearing seasons, to study rate of uzi–infestation at larval (4th and 5th) and cocoon stages in relation of the abiotic factors (temperature, humidity and rainfall) reveals a positive significant correlation coefficient among the factors. Minimum uzifly–infestation was 0.12% in February 1991 at 4th instar and maximum infestation of 7.30% was recorded in July 1991 at 5th instar. A multiple regression equation was fitted for predicting the rate of uzifly–infestation in different seasons. Estimation of cocoon crop loss by uzifly attack in Murshidabad District showed crop loss to an extent of 19.70%.

Keywords: Uzifly, silkworm, infestation rate, cocoon rate, cocoon crop loss.)

Introduction

Uzifly, *Exorista bombycis* (Louis) is an economically important parasitoid of silkworm. *Bombyx mori* L, posing serious threat to silk industry in the eastern and north–eastern regions of India, particularly in West Bengal, Bihar and Assam (Mukherjee, 1912; Jameson, 1922 and Dasgupta, 1962). Sriharan *et al.* (1971) reported its distribution through out the sericultural tract of eastern India. Ghosh (1949) indicated that it is prevalent in many other east Asian countries too. *E. bombycis* was first reported from Karnataka in May 1980 (Jolly, 1981). Since then, sericultural industry of southern India, which contributes over 88 per cent of the country's total cocoon production, has been suffering from uzifly attack.

Loss of cocoon crops due to uzi–infestation is a recurrent problem in traditional sericultural districts of West Bengal. Murshidabad, being one of such districts, often faces serious loss in cocoon production caused by the parasitoid. Review of literatures reveal that in 19th century, in Bengal, annual loss due to this parasitoid was estimated between $ 200,000 to 300,000 with a loss of Rs. 500,000 recorded in a single

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Table 1. Meterological data of Murshidabad District during different commercial rearing seasons for 1991-1992

Season of rearing	Maximum Temperature (°C)	Minimum Temperature (°C)	Maximum R. Humidity (%)	Minimum R. Humidity (%)	Average Rainfall (mm)
JAN–FEB 91	24.40	20.10	69.80	56.40	0.38
APR 91	32.40	26.70	69.10	49.50	0.43
JUL 91	31.90	27.50	85.60	75.70	5.39
SEP 91	30.70	28.30	88.70	80.90	14.40
NOV 91	24.10	21.20	66.80	56.10	0.00
JAN–FEB 29	22.71	18.95	68.23	51.57	0.25
APR 92	33.66	26.61	65.27	43 68	0.20
JUL 92	30.85	26.95	82.62	71.75	19.35
SEP 92	30.55	27.55	69.52	58.23	4.57
NOV 92	25.80	22.00	55.44	43.50	0.40

crop (Cotes, 1889 and Louis, 1880), Maxwell–Lefroy (1917) stated that this fly was responsible for 15 to 20 per cent in different rearing seasons. Krishnaswami *et al.* (1964) surveyed the extent of uzi–infestation in Malda District during May to December in 1962. Murty *et al.* (1988) estimated the range of uzi–infestation in West Bengal and Andhra Pradesh. Bhattacharya *et al.* (1993 b) made a thorough survey in commercial sericultural areas of Malda District from May 1988 to February 1990 and recorded uzi–infestation ranging from 0.008 to 11.6 per cent depending upon rearing seasons. They also assessed crop loss due to uzi attack to be 12. 25 per cent.

The present text details incidence of uzi–infestation and cocoon crop loss in different commercial rearing seasons in Murshidabad District successively from February 1991 to November 1992, since cropping patterns in Malda and Murshidabad vary considerably. A multiple regression equation is fitted to predict rate of uzi–infestation as well as crop loss with reference to influence of abiotic factors like temperature, humidity and rainfall prevailing in different seasons.

Materials and Methods

Survey of uzi–infestation on silkworm was carried out in Murshidabad District during February 1991 to November 1992 covering twice annual commercial crop schedule of 5 rearing seasons such as February crop (Chaitra), April crop (Baisaki), July crop (Ashadi) September crop (Aswina) and November crop (Agrahayani). Five Per cent of total sericultural villages of Nabagram and Khargram blocks of the said district were randomly selected, where uzi–infestation is a regular phenomenon and 5 per cent of rearing houses were drawn from every selected village. From every selected rearing house 400 worms were examined at random once during each of 4th and 5th instars; a sample of 400 cocoons was taken at random from total harvest for studying the rate of uzi–infestation on the basis of symptoms of black scars on larval bodies and uzi pierced cocoons, since uzi–infestation is found to be maximum in these stages.

Date of brushing and meteorological data (Table 1) in respect of temperature,

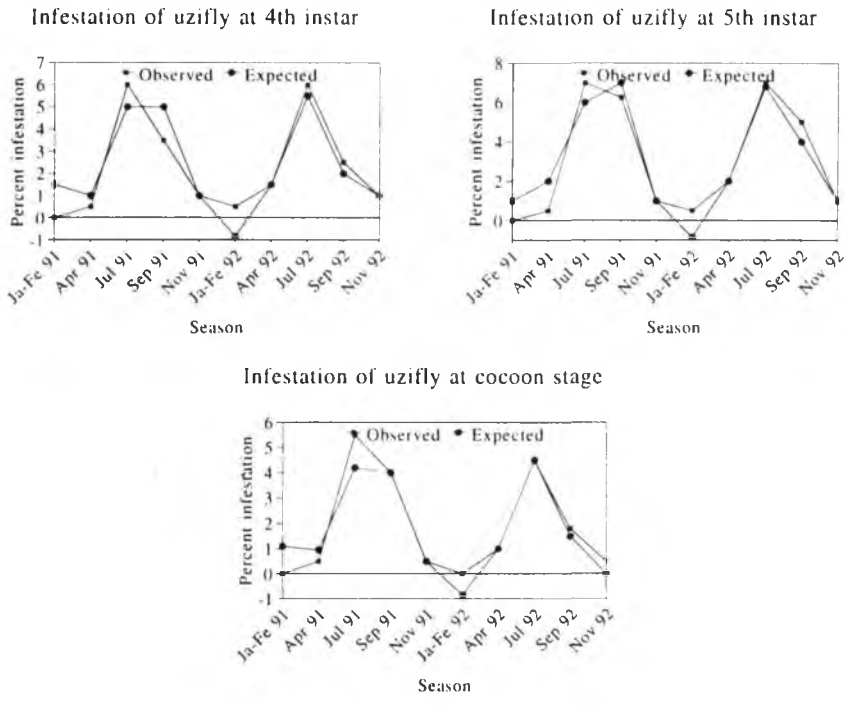

Fig. 1. Uzifly-infestation (%) in commercial zones of Murshidabad District during 1991–92

relative humidity and rainfall for every commercial rearing season were noted. Assessment of crop loss (%) was calculated from ratio of number of worms infested to total number of worms reared, both expressed in terms of disease free layings (1 dfl ≈ 400 worms). Estimates for mean and variance were calculated as per Sukhatme *et al.* (1984). Also, multiple regression equation is fitted to predict rate of uzi-infestation in relation to influence of abiotic factors in different seasons for different stages of silkworms.

Results

Rates of uzi-infestation, both observed and predicted during 4th and 5th larval and cocoon stages are resolved into Fig I.

During 4th instar, minimum infestation (0.12 % to 0.41%) was recorded during January–February. Thereafter the infestation gradually increased to crest by 6.22% during July.

During 5th instar, minimum infestation (0.17% to 0.50%) was seen in January–February and maximum infestation of 6.88% to 7.30% during July. Similarly, minimum infestation (0.15% to 0.16%) at cocoon stage was also observed during January–February and maximum in July (4.58% to 5.55%).

Correlation coefficient for assessment of relationship between uzi–infestation and abiotic factors was calculated (Table 2). The rate of uzi–infestation at 4th and 5th instars and cocoon stage is positively and highly correlated with temperature. humidity

Table 2. Correlation coefficient of uzi-infestation rate with abiotic factors and DFLs reared for different developmental stages of silkworm

Stage	Maximum Temperature (°C)	Minimum Temperature (°C)	Maximum R. Humidity (%)	Minimum R. Humidity (%)	Average Rainfall (mm)	Dfls reared
IV	0.457**	0.578**	0.713**	0.721**	0.552**	– 0.159**
V	0.521**	0.678**	0.730**	0.745**	0.476**	– 0.146**
Cocoon	0.442**	0.561**	0.728**	0.731**	0.409	– 0.140**

** Significant at 1% level

Table 3. Regression equation for predicting uzi-infestation for any given season for different development stages of silkworms

Stage	Equation	R-square
IV	$Y = -3.867 + 1.095x_1 - 1.023x_2 - 0.330x_3 + 0.393x_4 + 0.120x_5$	0.706**
V	$Y = -8.670 + 0.466x_1 - 0.131x_2 - 0.234x_3 + 0.307x_4 + 0.082x_5$	0.718**
Cocoon	$Y = -5.833 + 0.946x_1 - 0.877x_2 - 0.263x_3 + 0.354x_4 + 0.054x_5$	0.648**

** Significant at 1% level

and rainfall. This agrees with observation of Bhattacharya *et al.* (1993 b). With a view to predicting uzi-infestation at 4th and 5th instars and cocoon stage in relation to abiotic factors a multiple regression equation was fitted and respective coefficients of determination (R^2) are presented in Table 3. The coefficient of determination (R^2) was 0.706 for 4th instar, 0.718 for 5th instar and 0.648 for cocoon stage, indicating predictability of uzi-infestation with reference to abiotic factors. Efficacy of fitted equation furnished in Table 4 reflects validity due to close relationship between predicted and observed values for the 4th and 5th instars and cocoon stage.

Estimation of crop loss due to uzi-infestation calculated for 10 different seasons in Murshidabad District on the basis of cluster sampling (Table 5) show that percentage crop loss was minimum (0.46% to 1.06%) in January–February and maximum (17.66% to 19.07%) in July.

Table 4. Comparison of the predicted and observed infestation rate in three developmental stages

Season of rearing	Observed Infestation (%)			Expected Infestation (%)		
	Stage IV	Stage V	Cocoon Stage	Stage IV	Stage V	Cocoon Stage
JAN–FEB 91	0.12	0.17	0.16	1.45	1.11	1.21
APR 91	0.60	0.90	0.44	0.99	2.02	0.74
JUL 91	6.22	7.30	5.55	5.06	6.28	4.75
SEP 91	3.56	6.07	3.85	5.02	7.22	4.43
NOV 91	0.93	0.99	0.43	0.82	1.40	0.62
JAN–FEB 92	0.41	0.50	0.15	–0.62	–0.66	–0.68
APR 92	1.16	1.95	0.85	1.41	1.71	0.95
JUL 92	6.22	6.85	4.58	5.57	6.48	4.39
SEP 92	2.46	4.93	1.52	1.87	3.97	1.44
NOV 92	0.60	0.77	0.38	0.71	0.91	0.09

Table 5. Assessment of crop loss due to uzi-infestation

Season of rearing	Total Rearing Houses	Sample Rearing Houses	Average Cocoon Yield/100 Dfls(kg)	DFL's reared	Infested worms/100 dfl			SD* of Infested worms			Total DFL's Infested	Crop loss%
					Stage IV	Stage V	Cocoon Stage	Stage IV	Stage V	Cocoon Stage		
JAN–FEB 91	835	43	24.50	174.42	49.30	69.77	64.19	62.11	67.98	59.85	667.23	0.46
APR 91	822	43	23.00	151.74	239.07	360.00	177.67	196.81	205.78	146.22	2422.15	1.94
JUL 91	798	43	21.50	137.79	2488.37	2918.14	2220.47	1233.99	1431.03	1429.58	20965.98	19.07
SEP 91	810	43	22.30	147.09	1423.26	2429.77	1541.40	314.04	756.55	540.76	16068.00	13.49
NOV 91	820	43	24.00	170.93	373.02	394.42	170.23	113.05	130.99	88.44	3285.68	2.34
JAN–FEB 92	831	43	25.00	175.58	162.79	199.07	61.40	120.89	146.52	59.98	1543.91	1.06
APR 92	820	43	23.50	152.91	464.19	779.53	341.40	275.94	244.97	127.76	4968.69	3.96
JUL 92	808	43	21.00	150.00	2489.30	2741.40	1832.56	551.49	599.18	445.61	21401.67	17.66
SEP 92	815	43	21.80	151.16	982.33	1972.09	608.37	338.24	560.70	201.86	10973.19	8.91
NOV 92	825	43	22.50	166.28	214.86	307.91	152.56	87.95	85.20	56.74	2408.63	1.76

* Standard deviation

Discussion

Bhattacharya *et al.* (1993 b) reports maximum infestation (11.6%) of uzifly in May during 5th instar in Malda District while the present investigation shows maximum infestation (7.30%) in July during 5th instar in Murshidabad District.

General trend of incidence of uzi–infestation with reference to different commercial rearing seasons reflects that infestation being low during winter (November to February), gradually increase with rise in temperature, humidity and rainfall in following seasons. The infestation was recorded maximum during rainy season (July to September). The present observations indicate that extent of cocoon crop loss due to uzi–infestation in Murshidabad District was higher (19.07%) than in Malda District (12.25%). Murshidabad District follows a separate crop schedule of 5 rearing seasons against 4 of Malda District. Besides, in many villages of Murshidabad District, farmers harvest unrecognized sixth or seventh crop a year without following any schedule of brushing that makes overlapping silkworm rearings throughout the year. Thus, the uzifly on emergence finds host at suitable stages for oviposition, causing higher rate of infestation in Murshidabad District. In opposition, Malda District farmers impose rearing holiday for every crop maintaining a gap of 2.5 to 3 months between each crop that reduces rate of uzi–infestation. Bhattacharya *et al.* (1993 a) reported that temperature and humidity ranging from 27.2°C to 30.2°C and 80.3% to 88.7% respectively, are congenial to generation survivability of uzifly. The present study is in agreement with the observation since similar abiotic conditions prevailed in commercial sericultural zones of Murshidabad District during July–September.

The present study resulted in application scope of multiple correlation for temperature, humidity and rainfall and incidence of uzi–infestation that helps prepare a calendar for fore–warning system to control uzifly in Murshidabad District.

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References

Bhattacharya, S. S., N. Chakraborty and A. K. Sahakundu (1993) a) Life table of the uzifly, *Exorista sorbillans* (Wiedemann) (Diptera: Tachinidae) a parasitoid of the mulberry silkworm, *Bombyx mori*, *Sericologia*, **33(1)** 65–74.

Bhattacharya, S. S., N. Chakraborty and A. K. Sahakundu (1993 b) Influence of abiotic factors on uzifly, *Exorista sorbillans* (Wiedemann), Beck, infestation on the silkworm (*Bombyx mori* L.) and assessment of crop loss in Malda District (West Bengal, India). *Sericologia*, **33 (2)**, 289–296.

Cotes, E. C. (1889) Entomology notes. 1. *Trycolyga bombycis*, *Indian Mus. notes*. **1 (2)**, 77–81 and 83–88.

Dasgupta, K. P. (1962) Observations on the behaviour of uzifly maggots. *Indian J. Seric.*, **1 (2)**, 16–18.

Ghosh, C. C. (1949) Silk Production and Weaving in India, Govt. Printing Press, Calcutta, 1–232.

Jameson, A. P. (1922) Report on the diseases of silkworm in India. Govt. Printing Press, Calcutta, 62–64.

Jolly, M. S. (1981) Uzifly and its identification, prevention and control Bull. of C. S. R. and T I., Mysore, 4.

Krishnaswami, S., M. S. Jolly and K. Datta (1964) A study on the fly pest infestation of the larvae and cocoon of *Bombyx mori* L. *Indian J. Seric.*, **3**, 7–12.

Louis, J. A. H. (1880) A few words on the present state and future prospects of sericulture in Bengal, Civil Service Printing and Publishing Co., Ltd., London, 31pp.

Maxwell–Lefroy, H. M. (1917) The silk industry, Govt. Printing, Calcutta, 211 pp.

Mukherjee, N. G. (1912) Handbook of Sericulture, Bengal Secretariat Book Depot, Calcutta, 119 pp.

Murty, S. V., K. N. Jyothi and K. Jamil (1988) Environmental factors governing the infestation of uzi–fly *Exorista sorbillans*, an endoparasite of mulberry silkworm *Bombyx mori*, in certain areas of West Bengal and Andhra Pradesh, Proc. National Symposium on Nutritional Ecology of insects and Environment, Muzaffarnagar.

Sriharan, T. P., M. V. Samson, S. Krishnaswami and R. K. Datta (1971) Laboratory investigation on uzifly *T. bombycis* Beck, a Tachinid parasite of silk worms (*Bombyx mori* L.) *Indian J. Seric.*, **10 (1)**, 14–22.

Sukhatme, P. V., B. V. Sukhatme and C. Asoke (1984) Sampling theory of survey with applications, Iowa State Univ. press and ISAS, New Delhi, 526 pp.

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Trophic Relations of Aphid Hyperparasitoids in Northeastern Uttar Pradesh

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Abstract: During the extensive survey of northeastern U. P., six species of hyperparasitoids were recorded viz., *Aphidencyrtus aphidivorus* (Mayr), *Syrpophagus hofferi* (Hayat), *Chartocerus walkeri* (Hayat), *Alloxysta pleuralis* (Cameron), *Phaenoglyphis* sp. and *Pachyneuron aphidis* (Bouche). Some of them show new host associations in multitrophic relations. The extent of hyperparasitism varied in different habitats. *A. pleuralis* and *Phaenoglyphis* sp. are abundant in most of the target areas and may thus hinder the action of the parasitoids.

Keywords: Aphids, parasitoids, hyperparasitoids.

Introduction

Hyperparasitoids may adversely affect the biological control programme because they help the phytophages by reducing their natural enemies (McAllister and Roitberg, 1987). In natural systems, the parasitoids protect themselves from hyperparasitism by modifying the behaviour of the host (Brodeur and Mcneil, 1992). Luck *et al.* (1981) suggested that the hyperparasitoid may play a positive role in maintaining the proper balance between the density of parasitoid and its host by checking the excessive build up of the parasitoid's population.

The survey and identification of the pest–complex and their natural enemies in the target area are considered as the first step in a biological control programme. Therefore, different localities of northeastern Uttar Pradesh viz., Gorakhpur, Deoria and Mehrajganj were surveyed in different seasons to get information on aphids, their parasitoids and hyperparasitoids interaction for evaluation in biological control programme. Twenty five species of aphids infesting 78 food plants, 13 species of their parasitoids and 6 species of hyperparasitoids were recorded in the target area with several new host associations. (Ahmed and Singh, 1992, 1993).

Materials and Methods

The records of hyperparasitoids were made by sampling of aphids in different localities of the target area. The parts of food plants bearing aphids were transported to the laboratory in plastic bags. Alive aphids or mummies were put into plastic vials (2.5 × 10 cm or more) along with the food plants, covered with muslin cloth and kept in BOD incubator at 22°C ± 1 for development until adult emergence. The parasitoids

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and hyperparasitoids were collected by suction collector and preserved in 70% ethyl alcohol for identification.

Results and Discussion

Taxonomical study of emerged hyperparasitoids revealed the presence of six species of hyperparasitoids viz., *Aphidencyrtus aphidivorus* (Mayr), *Syrpophagus hofferi* (Hayat), *Chartocerus walkeri* (Hayat), *Alloxysta pleuralis* (Cameron), *Phenoglyphis* sp, *Pachyneuron aphidis* (Bouche). Some of these demonstrate new host associations (Table). These hyperparasitoids belong to only two superfamilies: Cynipoidea and Chalcidoidea (Table). Members of Ceraphronoidea viz., *Aphanogmus* sp., *Ceraphron* sp. and *Denrocerus carpentri* (Curtis) were recorded earlier from the target area (Singh *et al.* 1982) but they were not recovered in the present extensive survey (Figure).

Records of Aphid Hyperparasioids from the target area

Hyperparasitoid – Parasitoid – Host aphid – Food plant	Period of occurrence
A. SUPERFAMILY : CHALCIDOIDEA	
I. Family : Encyrtidae	
1. *Aphidencyrtus aphidivorus* (Mayr)	
**Trioxys indicus* Subba Rao & Sharma	Dec. – Jan.
Aphis gossypii Glover	
**Momordica charantia*	
(Cucurbitaceae)	
2. *Syrpophagus hofferi* (Hayat)	
Lipolexis scutellaris Mackauer	Nov. – Jan.
**Aphis craccivora* Koch	
**Dolichus lablab*	
(Fabaceae)	
II. Family : Pteromalidae	
3. *Pachyneuron aphidis* (Bouche)	
Diaeretiella rapae	Mar. – Apr.
Brevicoryne brassicae	
Brassica oleracea var.	
capitata (Brassicaceae)	
Family : Signiphoridae	
4. *Chartocerus walkeri* Hayat	
Trioxys indicus	Feb. – Apr.
**Aphis nerii* Boyer de Fonsc.	
**Calotropis procera*	
(Asclepiadaceae)	
B. SUPERFAMILY : CYNIPOIDEA	
I. Family : Charipidae (=Alloxystidae)	
5. *Alloxysta pleuralis* (Cameron)	
Lipolexis scutellaris	Nov. – Jan.
**Aphis nasturtii Kaltenbach*	

Luffa cylindrica	
(Cucurbitaceae)	
Trioxys indicus	
Aphis craccivora	
Cajanus cajan	Jan. – Apr.
(Fabaceae)	
Lagenaria vulgaris	Nov. – Jan.
(Cucurbitaceae)	
Solanum melongena	Jan. – Feb.
(Solanaceae)	
Aphis gossypii	
Cajanus cajan	Jan. – Apr.
**Aphis nerii*	
Calotropis procera	Feb. – Apr.
**Aphis fabae*	
Clerodendrum viscosum	Feb. – Mar.
6. *Phaenoglyphis sp.*	
Trioxys indicus	
Aphis craccivora	
**Ageratum conyzoides*	Jan. – Mar.
(Asteraceae)	
**Solanum melongena*	Jan. – Mar.
**Aphis nerii*	
Calotropis procera	Feb. – Apr.

* New host association.

Most of the collected hyperparasitoids have more than one host association (Table) and have high variations in the attack rate on different aphid species through several parasitoid species on different food plants (Table). Sometimes the hyperparasitisation rate was highly variable even on the same parasitoid, aphid and food plant complex in different localities. Detailed accounts of the hyperparasitoids follows:

A. Superfamily: Chalcidoidea

(a) Family: Encyrtidae

This family has only five genera of aphid hyperparasitoids and all are reported from India viz., *Aphidencyrtus, Litomastrix, Prionomites, Syrpophagus* and *Tassonia* (Singh and Tripathi, 1991) among which four genera are reported from the target areas (Figure). In the present survey, however, only two species viz., *A. aphidivorus* and *S. hofferi* were recorded. The other species recorded by Singh *et al.* (1982) and Singh and Tripathi (1988) were not recovered. These species were recorded earlier as hyperparasitic/parasitic on other than aphid hosts (Gordh, 1981); therefore, their status as hyperparasitoids is doubtful.

1. Aphidencyrtus aphidivours (Mayr) *A. aphidivorus* is a widely distributed solitary hyperparasitoid attacking six aphidiine (Family: Braconidae) hosts in India (Singh and Tripathi, 1991). It is recorded for the first time from Uttar Pradesh on *Trioxys*

Fig. 1. Records of hyperparasitoids of the Aphids through Aphidiid parasitoid in the target area

indicus through *Aphis gossypii* (Table). *T. indicus* also serves as new host. The intensity of the hyperparasitisation was moderate (40–60%).

Earlier studies on the biology of *A. aphidivorus* have demonstrated dual oviposition behaviour of the female (Sullivan, 1981). Female wasps attack and oviposit into both live parasitized aphid and dead parasitized aphid (mummified aphid) (Matesson, 1977). Recently Kanuck and Sullivan (1992) observed that 82% of the females attack the mummified aphid while only 18% choose the live parasitized aphids for oviposition.

2. *Syrpophagus hofferi (Hayat)* *S. hofferi* was described by Hayat (1972) from India as *Aphidencyrtus hofferi*, but later it was placed in genus *Syrpophagus*.

In the present study, it was observed on two parasitoid species viz., *Lipolexis scutellaris* and *T. indicus* through *Aphis craccivora* and *A. gossypii*, respectively. The low (10–40%) level of hyperparasitism was recorded. Earlier it was recorded on *L. scutellaris* through *Myzus persicae, Lysiphlebus delhiensis* through *Rhopalosiphus maidis* and *T. indicus* through *A. gossypii* from the target area (Singh and Tripathi, 1991). Recently Tripathi *et al.* (1992) recorded the species on *Diaeritiella rapae* through *Lipaphis erysimi*.

(b) Family: Pteronalidae

It is a small family including three genera of aphid hyperparasitoids viz., *Asaphes, Coruna* and *Pacyneuron*. Only *Pacyneuron* was recorded from the target area.

3. *Pachymeuron aphidis (Bouche)* Pandey *et al.* (1985) reported it from the target area parasitising the larvae of *D. rapae* through *L. erysimi*. In the present study only a few specimens were obtained from the mummies of *D. rapae* through *Brevicoryne brassicae*. *B. brassica* serves as new host (Table).

(c) Family: Signiphoridae

It is one of the smallest families in Chalcidoidea, with only one genus, *Chartocerus* being aphid hyperparasitoids.

4. Chartocerus walkeri Hayat It is a little known hyperparasitoid of aphids. In the present study, only a few specimens were obtained from *T. indicus* through *Aphis nerii*. Both aphid and food plants serve a new host combination (Table). It was earlier reported in this area on *T. indicus* through *A. gossypii* infesting *Luffa cylindrica* and *Solanum melongena* (Singh and Tripathi, 1988).

B. Superfamily: Cynipoidea

This is a large group of minute insects usually dark black or yellowish in colour. the various species are gall makers, inquilines or parasitic/hyperparasitic (Gordh, 1981). The family Charipidae is the only family which consists of aphid hyperparasitoids (Figure).

(d) Family: Charipidae

Charipids are widely distributed group of aphid hyperparasitoids. Only three genera viz., *Alloxysta, Lytoxysta* and *Phaenoglyphis* are hyperparasitoids. Andrews (1978) described the taxonomy and host specificity of Nearctic charipids and has given a catalogue of world species.

In India, only two species *A. pleuralis* and *Phaenoglyphis* sp. were recorded so far. These are found abundantly in the target area (Figure).

5. Alloxysta pleuralis (Cameron) *A. pleuralis* was reported from India by Singh and Sinha (1979) as a hyperparasitoid of *T. indicus* through *A. craccivora*. It is one of the most common polyphage in a number of habitats.

It begins to appear during last week of November and continues to build up the population up to April. Higher degree of hyperparstitism was observed in the fields of *Cajanus cajan* on *T. indicus* through *A. craccivora* during the last week of February to mid March. Due to high degree of hyperparsitisation very few parasitoids emerged from the mummies during last half of March. This indicates that high population of hyperparsitoid retards the population of the parastioid. The detailed biological study of *A. pleuralis* was conducted by Singh and Srivastava (1988, 1989, 1990).

6. Phaenoglyphis Sp. *Phaenoglyphis* sp. is widely distributed in India. In the present survey, it was observed on a number of aphid hosts and food plants (Table). *T. indicus* through *A. nerii* infesting *Calotropis procera* and *A. craccivora* infesting *Solanum melongena* and *Ageratum conyzoides* constitute new complexes.

It is also found mostly during last week of December to February. The extent of hyperparasitisation was found always high in most of the target areas.

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References

Ahmad, M. E. and R. Singh (1992) Recent records of aphids of northeastern Uttar Pradesh. *Newsl. Aphidol. Soc., India*, **10** (2): 7–10.

Ahmad, M. E. and R. Singh (1993) Host associations of Aphidiid parasitoid of northeastern Uttar Pradesh. *J. Aphidol.*, In press.

Andres, F. G. (1978) Taxonomy and host specificity of Nearctic Alloxystinae with a catalogue of the world species (Hymenoptera: Cynopoidea). *State Calif. Dep. Food Agric. Occ. Paper Ent.*, **25**: 1–128.

Brodeur, J. and J. N. McNeil (1992) Host behaviour modification by the endoparasitoid *Aphidius nigripes*, a strategy to reduce hyperparasitism. *Ecol. Ent.*, **17**: 97–104.

Gordh, G. (1981) The phenomenon of insect hyperparasitism and its taxonomical occurrence in the Insecta. In: *The role of hyperparasitism in biological control: Symp. Univ. Calif.*, Berkeley: 10–18.

Hayat, M. (1972) A new and a known species of Encyrtidae (Hymenoptera: Chalcidoidea) from India. *Proc. Zool. Soc. Calcutta*, **25**: 35–38.

Kanuck, M. J. and D. J. Sullivan (1992) Ovipositional behaviour and larval development of *Aphidencyrtus aphidivorus* (Hymenoptera: Encyrtidae), an aphid hyperparasitoid. *J. New York. Ent. Soc.* **100**: 527–532.

Luck, R., P. S. Messenger and J. F. Barbieri (1981) The influence of hyperparasitism on the performance of biological control agents, In: *The role of hyperparasitism in biological control: Sym. Univ. Calif.* Berkeley: 34–42.

Metesson, P. C. (1977) A study of aphid parasite compeexes, with special reference to the hyperparasite, *Aphidencyrtus aphidivorus* (Mayr), (Hymenoptera: Encyrtidae) Ph. D. dissertation, University of California, Nerkeley, **112** pp.

McAllister, M. K. and B. D. Roitberg (1987) Adaptive suicidal behaviour in pea aphid. *Nature*, **328**: 797–799.

Pandey, K. P., A. Kumar, S. Shanker and C. P. M. Tripathi (1985) First record of *Pachyneuron aphidis* (Bouche) (Pteromalidae: Hymenoptera), a hyperparasitoid of *Diaeretiella rapae* (Mcltosh) (Aphidiidae: Hymenoptera) from India. *Curr. Sci.*, **54**: 710.

Singh, R. and T. B. Sinha (1979) First record of *Alloxysta* sp. a hyperparasitoid of *Trioxys indicus* Subba Rao and Sharma (Aphidiiae: Hymenoptera). *Curr. Sci.*, **48**: 1008–1009.

Singh, R. and P. N. Srivastava (1988) Host acceptance behaviour of *Alloxysta peuralis*, a cynipoid hyperparasitoid of an aphidiid parasitoid *Trioxys indicus* on aphids. *Ent. Exp. Appl.*, **47**: 89–94.

Singh, R. and P. N. Srivastava (1989) Life table studies of an aphid hyperparasitoid *Alloxysta pleuralis* (Cameron) (Alloxystidae: Hymenoptera). *J. Appl. Ent.*, **70**: 357–366.

Singh, R. and P. N. Srivastava (1990) Host specificity and seasonal distribution of *Alloxysta pleuralis* (Cameron), a cynipoid aphid hyperparasitoid in India. *Ecol. Ent.*, **15**: 215–224.

Singh, R. and R. N. Tripathi (1988) New host association of the parasitoid and hyperparasitoid of aphids from India. *Newsl. Aph. Soc. India*, **8**: 6–8.

Singh, R. and R. N. Tripathi (1991) Records of aphid hyperparasitoids in India. *Bioved*, **1**: 141–150.

Singh, R., R. K. Pandey and T. B. Sinha (1982) First record of three hyperparasitoids of *Trioxys (Binodoxys) indicus* Subba Rao and Sharma (Hym.: Aphidiidae) from India. Entomon, **7**: 329–330.

Sullivan, D. J. (1987) Insect hyperparasitism. *Annu. Rev. Ent.*, **32**: 49–70.

Tripathi, s. P., M. K. Pandey and C. P. Tiwari (1992) New records of *Syrpophagus hofferi* (Hayat) hyperparasitoid on *Lipaphis erysimi* from Gorakhpur. *J. Adv. Zool.*, **13**: 59.

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Taxonomic Notes on *Culex* (Lophoceraomyia) *infantulus* Edwards (Diptera: Culicidae) Based on its New Distribution Record in Pondicherry, South India

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Abstract: A new distribution record of *Culex (Lophoceraomyia) infantulus* Edwards is reported based on its occurrence in Pondicherry, South India. Description of immature and adults from larvae collected and reared to adults is given. The need for specific identification of *C. infantulus* in India were it occurs sympatrically with the closely resembling *C. minutissimus* is emphasized. A modified key is provided for the purpose.

Keywords: *Culex infantulus*, taxonomy, male terminalia

Introduction

The ten Indian species of subgenus *Lophoceraomyia* of genus *Culex* described by Barraud (1934) did not include *C. infantulus*. Menon (1944) added *C. parainfantulus* as a new species, which was later synonomised with *C. infantulus* by Mattingly (1949). Sirivanakarn (1977) in his revision of the subgenus in the Oriental region, listed 14 species under *Lophoceraomyia* in India including *C. infantulus*, the distribution of which was cited as "Bombay: Kawar, N. Kanara: 1 male, 1 female". This species has not been reported subsequently in India, though many mosquito faunal surveys (Nagpal and Sharma, 1987; Nagpal *et al.* 1983; Dhanpal and Naik, 1986; Malhotra *et al.* 1987; Khamre and Kaliwal, 1988) were done in different parts of the country.

C. minutissimus which occurs sympatrically with *infantulus* (Sirivanakarn, 1977) has been recorded in Orissa (Nagpal and Sharma, 1983), Madhya Pradesh (Kulkarni and Rajput, 1989) and Goa (Kulkarni and Naik, 1989). Since the identification by these workers was based on the male antennal character described by Barraud (1934) which is essentially similar in both *minutissimus* and *infantulus*, there is reason to doubt that these may as well be *infantulus*. This is substantiated by the observation of Sirivanakarn (1977) that there are possibilities of some of the previous records of *minutissimus* from several localities in India by Barraud (1924, 1934), may actually be *infantulus*. Thus, confirmation of the wide distribution of *infantulus* and its specific identification in India has remained a necessity for long.

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The occurrence of *C. infantulus* is now confirmed based on collections made by the author in Pondicherry, South India, and reported here as a new distribution record. Selected characters of larva, pupa, female and male are described. A partial modification to the key of Barraud (1934) is made so as to include *C. infantulus*.

Materials and Methods

Material was obtained as larvae from wells in Bommiapalayam, a coastal village, 12 km away from the Pondicherry urban agglomeration. Water from wells, in this village which lies on the sandy shore, is mainly drawn for bathing and washing. Larvae were collected from four of eight such wells examined. These were reared individually in the laboratory and adults emerged were used for identification with associated larval and pupal skins. 4 males, 4 females, 3 larvae, 3 pupae and 4 male terminalia mounted on slide were examined. Confirmation of species was done based on the reticulate dorsal process of the phallosome which is the most distinctive character of *C. infantulus*. No adults were taken from the field. Specimens examined have been added to the collection at Vector Control Research Centre (VCRC), Pondicherry.

Description of Selected Characters

Female: Small, blackish mosquito. Head: Palp dark, 0.16–0.20 of proboscis length. Proboscis dark, with 4 basal bristles, 2 lateral ones being the longest. Palpal segments with small to moderate apical bristles. Vertex with erect dark scales interspersed with pale flat scales prominent around anterior margin of eyes. Thorax: Mesonotal scales brownish; numerous dark stout bristles on the lateral and posterior margins, few on the dorsum. Pleura light brown. Propleuron with 3 to 4 bristles, 2 always dark and strong. 1 lower mesepemeral bristle. Scutellar bristles 6 on midlobe and 3–4 on lateral lobes. Leg: Hind femur with anterior pale whitish stripe, not extending to the entire length. Abdomen: Terga dark with narrow basal transverse pale bands. Wings: dark scaled.

Male: Palp slightly longer than proboscis; segments 4 and 5 upturned, with conspicuous bristles, 2–3 spines at apex. Proboscis dark, with submedian false joint inconspicuous; labial basal setae 4–6, subequal in length. Antenna: flagellum densely plumose; modified tuft of setae on flagellomeres 7 and 8 (segments 8 and 9 of Barraud) only. Tuft on 8 with long stout setae; tuft on 7 much shorter. Other characters similar to female.

Male Genitalia: Basimere (coxite): submarginal setae 5–6 in number, 4 being strong and subequal in length, rest weak and shorter. Subapical lobe with 3 stout setae, apically hooked, 1 slightly broader, blade–like. 4–5 smaller, slender setae. Distimere (style) slender and curved with blunt subapical claw.

Phallosome: Dorsal beak–like process slender, long and reticulose. Proctiger: apex with a crown of 10–12 spicules.

Pupa: Essentially similar to description given by Sirivanakarn (1977) in the following features: Seta 10–C of metanotum double; seta 5–V 2–4 branched; setae 6 III–VI 4–6 branched.

Larva: Similar in characters described by Barraud (1934) for *minutissimus*, differing only in the lack of dark rings at the middle and base of siphon.

Key to Adults (Male) of *Lophoceraomyia.* (with couplets 1–4 of Barraud (1934) modified).

1 Abdomen with transverse basal pale bands on dorsum 2
Abdomen without pale bands on dorsum 5

2(1) Mesonotal scales dark brown or brownish black; flagellomere 6 of antenna without a bunch of crumpled scales 3
Mesonotal scales reddish brown; flagellomere 6 of antenna with a bunch of crumpled scales ..... *cinctellus*

3(2) Flagellomeres 6, 9 and 10 of antenna without modified thickened hairs; style tapering from base to apex 4
Flagellomeres 6, 9 and 10 of antenna with some fairly short, thickened hairs; style somewhat expanded on apical half ..... *seniori*

4(3) Dorsal beak–like process of phallosome long, slender, and reticulose; apex of proctiger with a crown of 10–12 spicules ..... *infantulus*
Dorsal beak–like process short and simple; apex of proctiger with a crown of 4–5 spicules ..... *minutissimus*

5(1) Torus of antennae without prominence 6
Torus of antennae with prominence 7

6(5) Palp with a small finger–like process at base; proboscis with a transverse row of about 6 fairly long stiff bristles on underside at base; antenna with a tuft of 12 or more long scales on segment 6 ..... *fraudatrix*
Palp without a finger–like process, but with two small dense projecting tufts of hair near base; proboscis with a transverse row of 10–12 stiff bristles on underside at base; antenna with about 3 long pointed scales on segment 6 ..... *rubithoracis*

7(5) Antenna with a tuft of long bright yellow hairs on segment 6 ..... *flavicornis*
Antenna with a tuft of dark brown hairs or scales on segment 6 8

8(7) Palp with a row of stiff bristles on outer side near base ..... *mammilifer*
Palp without a row of stiff bristles 9

9(8) Palp longer than proboscis by more than length of apical segment, last two segments distinctly hairy; antenna with a tuft of scales on segment 6, some of which are broad and very long ..... *uniformis*
Palp longer than proboscis by less than length of apical segment, last two segments with few hairs; segment 6 of antenna with a tuft of narrow hair–like scales all about same length ..... *minor*

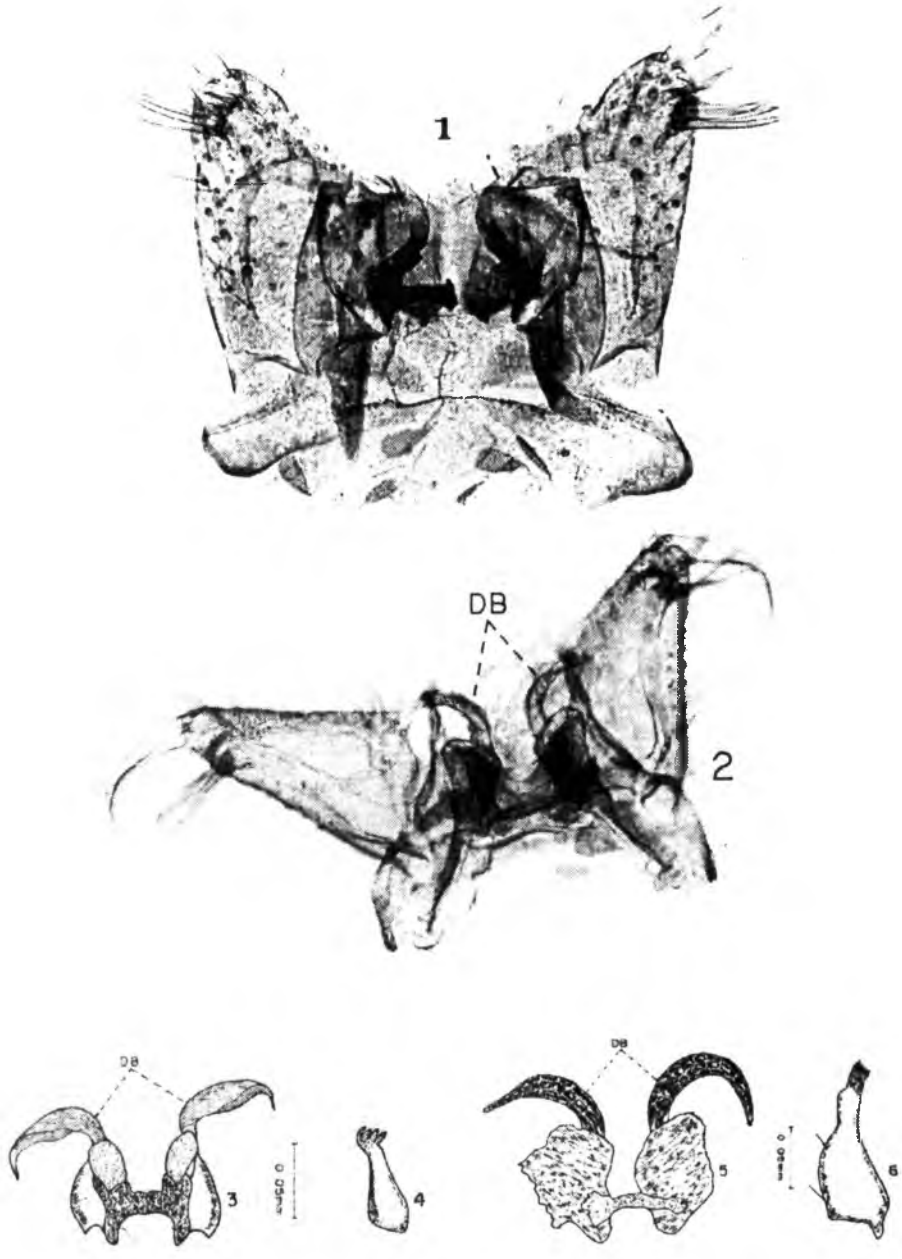

Fig. 1. Male terminalia of *Culex minutissimus*. Fig. 2. Male terminalia of *Culex infantulus*. DB–Dorsal beak like process of phallosome. Figs. 3–4. *Culex minutissimus*: 3. Phallosome; 4. Proctiger. Figs. 5–6. *Culex infantulus*: 5. Phallsome, 6. Proctiger; DB–Dorsal beak like process of phallosome

Taxonomic Discussion

In almost all species of subgenus *Lophoceraomyia*, specific identification of females remains difficult in the absence of males associated with larval and/or pupal skins. Among the two species *infantulus* and *minutissimus*, the similarities extend to immatures also. The male terminalia of *C. minutissimus* (Fig. 1) and *C. infantulus* (Fig. 2) differ from each other in the structure of phallosome and procitger (Figs. 3–6). Therefore, these characters are to be relied for differentiating these two species. Confirmation of the occurrence of *infantulus* in the region reported here is based on this diagnostic character. Description of larva and pupa has not been elaborated for two reasons. One, the specimens I have examined conforms with the description of *infantulus* given by Sirivanakarn (1977) and two, the larva is similar to *minutissimus* in all characters described by Barraud (1934) except for the lack of dark rings in the middle and base of the siphon.

The key of Barraud (1934) is used widely by several workers in India for identifying the culicines. Tripathy *et al.* (1989) have reported on karyotype of *C. minutissimus*, but their species identification remains doubtful as they have based it on Barraud (1934). A strong need for modification of this key is thus felt and accordingly I have reproduced the key to adults (males), with suitable alterations in couplets 1–4 to include *infantulus*. Removal of *plantaginis* from this key is justified as it has been synonomised with *minor* by Sirivanakarn (1977).

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References

Barraud, P. J. (1924) A revision of the culicine mosquitoes of India. Part XV. The Indian species of the subgenera *Lophoceratomyia* (Theo) Edw., including two new species. *Indian J. Med. Res.*, **12**, 37–46.

Barraud, P. J. (1934) The Fauna of British India including Ceylon and Burma, Diptera Vol. V: Family Culicidae, Tribes Megarhinini and Culicini. London: Taylor and Francis, 463 pp.

Dhanpal, J. and V. M. Naik (1986) Mosquitoes of Goa. *Indian J. Malariol.*, **23**, 39–42.

Khamre, J. S. and M. B. Kaliwal (1988) Mosquitoes of Daman. *Indian J. Malariol.*, **25**, 109–111.

Kulkarni, S. M. and P. S. Naik (1989) Breeding habitats of mosquitoes in Goa. *Indian J. Malariol.*, **26**, 41–44.

Kulkarni, S. M. and K. B. Rajput (1989) Day time resting habitats of culicine mosquitoes and their preponderance in Bastar District, Madhya Pradesh, India. *J. Com. Dis.*, **20**, 280–286.

Malhotra, P. R., P. K. Sarkar, N. G. Das, S. Hazarika and V. M. John (1987) Mosquito survey in Tirap and Subansiri districts of Arunachal Pradesh. *Indian J. Malariol.*, **24**, 151–158.

Mattingly, P. F. (1949) Notes on some Oriental mosquitoes. *Proc. Royal. Ent. Soc. Lond.* **18**, 219–228.

Menon, M. A. U. (1944) On a new species of the subgenus *Lophoceratomyia* Theobald 1905 (Diptera, Culicidae). *J. Mal. Inst. Ind.*, **5**, 389–393.

Nagpal, B. N. and V. P. Sharma (1983) Mosquitoes of Coastal Orissa. *Indian J. Malariol.*, **20**, 141–145.

Nagpal, B. N. and V. P. Sharma (1987) Survey of mosquito fauna of northeastern region of India. *Indian J. Malariol.*, **24**, 143–149.

Nagpal, B. N., Yogendra Kumar, Usha Sharma and V. P. Sharma (1983) Mosquitoes of Nainital Terai (U. P.). *Indian J. Malariol.*, **20**, 129–135.

Sirivanakarn, S. (1977) Medical Entomology Studies–VI. A revision of the subgenus *Lophoceraomyia* of the genus *Culex* in the Oriental region (Diptera; Culicidae). *Contrib. Am. Entomol. Inst.*, **13**, 1–245.

Tripathy, N. K., S. K. Chand and C. C. Das (1989) Chromosomal studies in *Culex minutissimus*. *Curr. Sci.*, **58**, 398–400.

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Two New Species of *Paratendipes* Kieffer (Diptera: Chironomidae) from the Duars of the Himalayas of West Bengal, India

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Abstract: *Paratendipes maculipennis* and *P. penicilliceps* are described as new species from the duars of the Himalayas of West Bengal.

Keywords: Chironomid midge, *Paratendipes*, Duars, Himalayas

The term, "Duars" etymologically means "door to Bhutan". comprises the area of terai covering the extension of Jalpaiguri district and entire areas of Coochbehar district. During this investigation of the chironomid fauna of this region of the Himalayas of West Bengal, two new species of genus *Paratendipes* Kieffer were collected at light which are described here. Six species of the genus were known from India namely, *digraphis* (Kieffer, 1911), *dolens* (Kieffer, 1910), *lahaulensis* (Singh, 1958), *hirsutus* (Guha and Chaudhuri, 1985), *pelargus* (Kieffer. 1913) and *unimaculipennis* (Chattopadhyay and Chaudhuri 1991).

Morphology and terminology used in describing the species are after Chaudhuri and Chattopadhyay (1990). All measurements are in millimeter (mm).

Holotypes of the species are kept with the collections of insects in the Department of Zoology (B. U. Ent.). University of Burdwan. Paratypes are deposited to the National Collections of insects (NZC). Calcutta and will be submitted to The Natural History Museum, London and United States National Museum, Washington D. C. in time.

1. Paratendipes maculipennis Dutta and Chaudhuri, new species

Male: Body length 2.17 (2.17–2.40. n=10), wing length 1.05 (0.99–1.07. n=10) and wing width 0.36 (0.36–0.37. n=10).

Head: Vertex with 16 (IV 8, OV 6, PO 2) setae. Corona with 4 large and 9–10 minute setae. Clypeus with 16 setae, clypeal ratio 0.75. Maxillary palp dark brown, palpomere III with 2 sickle–like sensillae, length ratio of palpomeres 1–V; 16: 13: 20: 25: 33, L/W ratio 1.53. Eyes reniform with a dorsomedian extension of 0.051. Antenna dark brown, length ratio of flagellomeres 1–XIII: 7:6:7:7:7:7:7:7:7:7:7:8:72. AR 0.85; CA 0.57; CP 0.84.

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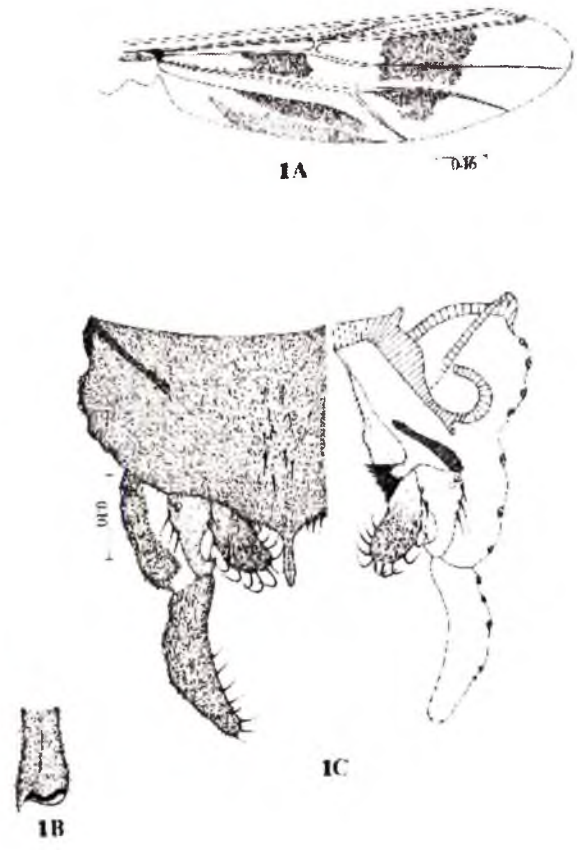


Fig. 1 A–E. *Paratendipes maculipennis* Dutta and Chaudhuri, new species. 1A. wing. 1B. fore tibial apex; 1C. male hypopygium; 1D. female antenna and 1E. female genitalia.

Thorax: Dark brown. Antepronotum with separate narrow emergination, antepronotal 0. Mesonotum with 3 dark vittae: acrostichals 10–11 biserial, dorsocentrals 12 uniserial, humeral 1, prescutellars 2, prealars 4 and scutellars 8 in a transverse row.

Wing: (Fig: 1A) with dense microtrichia and dark grey spots in the form of bands distributed as in the figure 1A. Brachiolum with 1 seta and 15–16 sensilla campaniformia: R_1 11 and R_1 and R_{1+5} without seta; R_{2+3} meets C at a distance of 0.009 from R_1; RM proximal to FCu. Haltere brown and bare. CR 1.04. VR 1.29.

Leg: Yellow with dark band at the apical third of femur, base of tibia fucous. Fore tibia with a pointed spur and 2 apical spur (Fig. 1B). Spurs of mid tibia unequal 0.018 and 0.012 long; spurs of hind tibiae also unequal 0.015 and 0.09 long. LR of fore leg 1.12, mid leg 3.82 and hind leg 3.26; BV of fore leg 2.03, mid leg 4.85 and hind leg 3.26; BR of fore leg 1.83, mid leg 1.80 and hind leg 2.16.

Abdomen: Dark brown with sparse dorsal setae arranged in characteristic pattern.

Hypopygium (Fig. 1C) light yellow and weakly built with tubular anal point 0.021 long bearing 4 setae at each basal margin. Gonocoxite short and massive with 8–10 setae over it; gonostylus short blunt little bent inward bearing 6–8 minute setae at its inner apical margin and about 28 setae. Superior volsella swollen at the base and hooked distally bearing 5–7 basolateral setae; inferior volsella short, little bent and with 24–26 small incurved apical setae; median volsella simple short and brush–like at the base of gonocoxite. HR 0.94. HV 3.10.

Female: Body length 2.46 (2.42–2.46. n-4), wing length 1.14 (1.12–1.14. n=4). Similar to male with usual sex differences. Antenna (Fig. 10) brown, flagellomeres II–III vase–like, flagellomere IV drum shaped: length ratio of flagellomeres I–V: 24:17:15:14:21. AR 0.30. Colour pattern of wing and legs more conspicuous than in male. Genitalia (Fig. 1E): Notum 0.12 long with bifurcated tip. Gonocoxapodeme VIII rounded. Coxosternapodeme stout, broad and bow–like. Gonapophysis VIII divided into a large massive dorsomesal lobe and a relatively small, oval ventrolateral lobe; apodeme long and weak. Postgenital plate V shaped. Seminal capsule subequal, oval measuring 0.05 by 0.04 and 0.06 by 0.05 respectively, ducts of capsule without loop and joined together in an ampulla before opening to the vagina. Cerci finely setose.

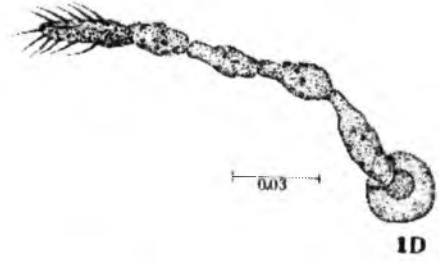
Material examined: Holotype male (Type no. 213. B. U. Ent.). Chalsa, 15.x.1986. Coll. T. K. Dutta. *Allotype* male, data same as holotype. *Paratype* 4 males, Tashigang, 8.viii.1984. Coll. T. K. Dutta; 8 males and 4 females, Raniganj, 21.ii.1977. Coll. R. K. Debnath.

Remarks: The species name *maculipennis* alludes to the spots on the wing. The character of the leg and structure of the hypopygium are related to *P. crosseyi* and *P. reidi* both described by Freeman (1957). It shares general appearance of male hypopygium with *P. seydii* Freeman and *P. striata* Kieffer from Africa. *P melanothorax* (Kieffer) from Nepal and *P. fuscitibia* Sublette (1960). The chaetotaxy of thorax and the colour pattern of legs of *P. hirsutus* Guha and Chaudhuri (1985) shows affinity with the present species. However, the following combination of characters distinguish *P. maculipennis* from other species of the genera: i) characteristic colour pattern of wings and legs. ii) fore tibia with a spur and 2 apical setae. iii) short, tubular anal point bearing 4 setae at each basal margin, iv) superior volsella swollen and apically hooked, v) inferior volsella short, little bent and with 24–26 small, incurved setae at its apex, vi) median volsella simple brush–like and vii) female genitalia with long and weak apodeme lobe.

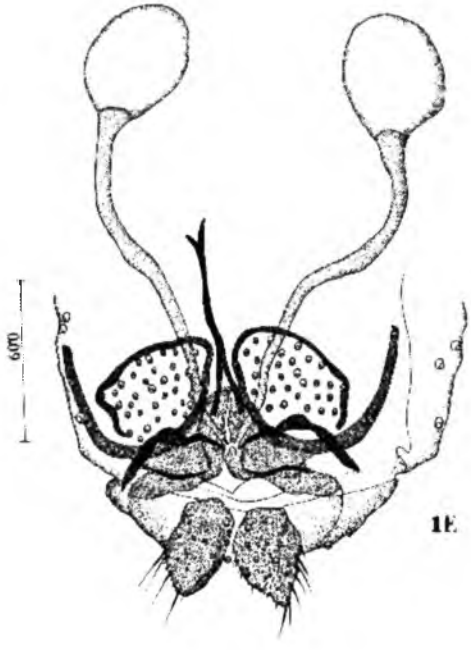
2. Paratendipes penicilliceps Dutta and Chaudhuri, new species

Male: Body length 2.54 (2.54–2.68, n=10), wing length 0.98 (0.98–1.08. n=10) and wing width 0.33 (0.33–0.38, n=10).

Head: Vertex with 9–10 (IV 2, OV 6, PO 2) setae. Corona with 4 large and 5–6 minute setae. Clypeus with 8 setae. clypeal ratio 1.42. Maxillary palp dark brown, palpomere III with 3 sensillae, length ratio of palpomeres I–V: 15: 10: 30: 31: 47, L/W ratio 3.75. Eyes reniform with a dorsomedian extension of 0.072. Antenna light brown, length ratio of flagellomeres I–XIII: 7: 6: 6: 5: 5: 5: 6: 6: 6: 6: 7: 7: 143. AR 1.98: CA 0.57: CP 0.90.



1D



1E

Thorax: Dark brown. Antepronotum separate with pronounced emergination, antepronotal 0. Mesonotum with 3 dark vittae; acrostichals 0, dorsocentrals 6 uniserial, humeral 1, prescutellars 1, prealars 3 and scutellars 4.

Wing: (Fig. 2A) Smoky with characteristic grey spots as in figure 2A and with conspicuous macro–and microtrichia. Brachiolum with 2 seta and 14–15 sensilla campaniformia; R, 7 and R_1 and R_{4+5} without seta: R_{2+3} meets C at a distance of 0. 18 from R_1: RM proximal to FCu. Squama fringed with 6 setae. Haltere brown and bare. CR 1.05. VR 1.16.

Leg: Femora and tibiae of mid and hind legs dark brown. Fore tibia with a subapical white band and a sharp spur bearing 2 setae at its base: fore and mid tarsomeres white, hind tarsomeres I–IV dark at its apices. Spurs of mid tibia equal

0.018 long; spurs of hind tibia unequal 0.021 and 0.015 long. LR of fore leg 1.92. mid leg 0.70 and hind leg 0.76; BV of fore leg 1.61, mid leg 3.58 and hind leg 3.02; BR of fore leg 1.20. mid leg 1.83 and hind leg 2.16.

Abdomen: Dark brown with numerous dorsal setae. Hypopygium (Fig. 2D) with long tubular anal point with little swollen distally and with 6 setae at its margin. Gonocoxite massive with about 19–20 setae over it; gonostylus moderate bluntly bent inward appearing as first parenthesis with 5–6 small setae at its inner apical margin. Superior volsella stout having a small apical outward hook bearing 5–6 setae; inferior volsella elongate and broad very little flexed outward having 41–42 long incurved apical setae; median volsella simple, perfectly brush–like. HR 1.05. HV 3.64.

Female: Body length 2.67 (2.65–2.67. n=4), wing length 1.28 (1.27–1.28. n=4) and wing breadth 0.47 (0.44–0.47, n=4). Similar to male with usual sex differences. Antenna (Fig. 2E) brown. flagellomere V little darker; length ratio of flagellomeres 1–V: 18:11:13:15:30. AR 0.52. Wing and legs similar to male with veins and spots of wing more conspicuous and darker. Genitalia (Fig. 2F): Notum 0.012 long. Gonocoxapodeme VIII rounded caudally and joined at the middle. Coxosternapodeme well developed and bow–like. Gonapophysis VIII divided into a large dorsomesal lobe and a small ventrolateral lobe; apodeme long, narrow and weak. Postgenital plate relatively small and narrowed down to assume V–shape. Seminal capsule nearly equal, more or less rounded 0.057 long by 0.048 wide, ducts of capsule without loop opening separately into the vagina, Cerci well developed and finely setose.

Material examined: Holotype male (Type no. 214, B. U. Ent.). Birpara, 20. iv. 1984. Coll. T. K. Dutta. *Allotype* female, data same as holotype. *Paratypes* 3 males and 3females, Buxaduar, 3.vi. 1984. Coll. T. K. Dutta: 4 males, Jayanti. 1.vi. 1984. Coll. T. K. Dutta; 8 males 1 female. Birpara, 20. vi. 1986. Coll. T. K. Dutta.

Remarks

In consideration of perfect brush–like median volsella of male hypopygium, the present species has been named *Paratendipes penicilliceps*. It looks closer to *P. tamayuabi* Sasa (1983) and *P. crosskeyi* in structure of gonocoxite, gonostylus, anal point and volsellae of male hypopygium. The species also resembles *P. duplicans* (Johannsen) and *P. inarmatus* Freeman in respect to superior and inferior volsellae. The species recalls *P. striata Kieffer* in the structure of gonocoxite, gonostylus and volsellae. However, the following combination of characters support its consideration as a new member of the genus *Paratendipes* Kieffer: i) vertex with 9–10 setae, ii) 4 scutellar setae, iii) wing and legs with characteristic colour pattern, iv) hypopygium with long tubular anal point with swollen distal and 6 basolateral setae, vii) gonostylus appearing as first parenthesis and viii) median volsella perfectly brush–like.

Acknowledgements

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References

Chattopadhyay, S. and Chaudhuri, P. K. (1991) A new species of genus *Paratendipes* Kieffer from Shillong, India. *Proc. Xth Int. Symp. Chironomidae*, Amsterdam, p. 10.

Chaudhuri, P. K. and Chattopadhyay, S. (1990) Chironomids of the rice paddy areas of West Bengal. India, *Tijdschr. voor Ent.*. **133 (2)**, 149–195.

Freeman, P. (1957) A study of Chironomidae (Diptera) of Africa south of Sahara III. *Bull. Br. Mus. nat. Hist. Ent.*, **5**, 323–426.

Guha. D. K. and Chaudhuri. P. K. (1985) *Paratendipes hirsutus* sp. nov. from India. *Acta Zool. Bulgarica*, **28**, 60–62.

Kieffer. J. J. (1910) Etude sur les Chironomides des Indes orientales, avec description de quelques nouvelles especes d. Egypte. *Mem. Indian Mus.*, **2**. 181–242.

Kieffer. J. J. (1911) Les Chironomides (Tendipedidae) de l' Himalaya et d' Assam. *Rec. Indian Mus.*, **6**, 319–349.

Sasa. M. (1983) Studies on Chironomid midges of the Tama river Part 5. An observation on the distribution of Chironominae along the main stream in June with description of 15 new species. *Res. Rept. Natl. Inst. Environ. Stud.*, **43**, 1–67.

Singh, S. (1958) Entomological survey of the Himalaya, 29. On a collection of nival Chironomidae (Diptera) from the north–west (Punjab) Himalaya. *Proc. natn. Acad. Sci.* India. **28**, 308–314.

Sublette. J. E. (1960) Chironomid midges of California–Chironominae, exclusive of Tanytarsini. *Proc. U. S. Nat. Mus.*, **112**, 197–226.

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Studies on *Botryoideclava bharatiya* Subba Rao, a parasite of sugarcane scale insect, *Melanaspis glomerata* (Green)

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Abstract: Studies conducted on the biology and laboratory multiplication of *Botryoideclava bharatiya* Subba Rao (Aphelinidae: Hymenoptera) show that it is a bisexual, gregarious ectoparasite of scale insect. Twenty five to thirty days' old scale insects at 1: 4 (Parasite: host) is found suitable for the multiplication of the parasite. Each female parasitises 7 to 21.5 scale insects under laboratory condition. At room temperature the female parasite lives for 1.25 to 1.50 days and male lives for about a day. The fecundity of the female is 36.16 eggs. The life cycle is completed in 23 to 27 days with three larval, prepupal and pupal stages. The stages are described in detail. The adult reproductive behaviour and host selection are also discussed.

Keywords: *Botryoideclava bharatiya–Melanaspis glomerata*, Biology, Host–parasite interaction.

Introduction

Thirty five species of scale insects infest stalks and leaves of sugarcane in the world and in India about fifteen species are reported to occur (Pruti and Rao, 1942; Rao and Sankaran, 1969; Easwaramoorthy and Kurup, 1986). Among them, the black scale insect, *Melanaspis glomerata* (Green) (Diaspididae) is a key pest of sugarcane in several states of the country. In recent years, attempts have been made to study the utility of natural enemies including parasites (Venkateswara Rao, 1983., Easwaramoorthy *et al.* 1986), predators (Sankaran and Mahadeva, 1974, Nageswara Rao, 1976., Seshagiri Rao *et al.* 1976, Raghunath and Rao, 1980) and pathogens (Raghavendran *et al.* 1988) for the control of this pest. Among the parasites, the aphelinid, *Botryoideclava bharatiya* Subba Rao was found to be important. It was originally described by Subba Rao (1980) from the scale insect, *Aclerda takahasi* Kuwana collected from Uttar Pradesh. This parasite was subsequently reported to occur on *M. glomerata* in eastern Uttar Pradesh (Misra *et al.* 1982), Gujarat, Madhya Pradesh and Andhra Pradesh (Easwaramoorthy *et al.* 1986). But, so far no detailed information is available on its biology and other aspects like host selection and parasitization under laboratory conditions. The details of investigations carried out on these aspects are described in this paper.

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Materials and Methods

Scale insect infested cane samples brought from different areas (Easwaramoorthy *et al.* 1986) were cut into pieces of 15 cm height. They were planted in moist sand beds, after sealing the top cut end with paraffin wax. The cane pieces were covered with a glass chimney, the mouth of which was covered with a muslin cloth. The emerging parasites were collected daily using an aspirator and the wasps of *B. bharatiya* were separated. This formed the nucleus culture. The multiplication technique of scale insect given by Easwaramoorthy and Shanmugasundaram (1991) was followed and an uninterrupted supply of host for the multiplication of the parasite was obtained. The optimum age of the host for the parasite multiplication was first worked out. For this, scale insects of different age groups viz. 20, 25 and 30 days were exposed for parasitization. The host population and the number of parasites released varied. From the 15th day after parasite release, emergence of the parasite was checked daily and the emerged parasites were collected. From the data obtained, the multiplication ratio was calculated.

In another experiment the optimum host: parasite ratio was worked out. For this, five levels of host population viz. 20, 40, 60, 80, and 100 were selected. Five males and 15 females were released within each chimney wherein cane pieces with the fourth instar scale insects were planted. Parasites were collected as mentioned earlier and the rate of multiplication was worked out.

Cane pieces containing female scales in the age group of 30–35 days were selected. After counting the host population, the cane pieces were planted in sand beds and covered with chimneys. A freshly emerged male and two females (simulating the natural sex ratio) were released for parasitization. After 20 days the scale insects were dissected and the number parasitized were observed. The treatments were replicated five times.

To study the longevity of the adults, five freshly emerged males and ten females were confined to glass tubes of size 8.5 × 1.4 cm. Food provided included 100 per cent honey and water in cotton swabs, sugar crystals and water, soaked raisins and water and no food (control). These glass tubes with parasites were kept at different temperatures (10°, 15°, 20°, 25° and 30°C) in B. O. D. incubators. The treatments were replicated thrice. Survival of the parasites was recorded daily.

Fecundity of the parasite was studied by releasing a single freshly mated female over a cane piece containing 8 to 10 female scale insects of 25 to 30 days age. The cane piece planted in the sand was covered with a polyester cage. The parasite was fed with 100 per cent honey and water through cotton swabs. After the death of the parasite, the scale insects were dissected and the number of eggs laid by the parasite were counted.

Observations were also made on various aspects of development of the parasite, mode of adult emergence, mating and reproductive behaviour, host finding and oviposition. The size of various developmental stages were determined and camera lucida drawings made.

Results

Parasite multiplication

Influence of host age

When the age of the host used for parasite multiplication was 30 days, sixteen fold increase in the parasite population was observed. The life cycle was completed in 18 days. It look 21 days for the parasite to complete one generation when the age of the host was 25 days and the multiplication rate increased only by ten fold. In 20 days' old host, life cycle of the parasite was prolonged to 28 days and the rate of multiplication was only 5 times (Table 1).

Table 1. Influence of age of the host insect, *M. glomerata* on the multiplication of the parasite, *B. bharatiya*

Age of the host (days)	Number of parasites released		Population of scale insect	Number of parasites recovered	Total	Multiplication ratio
	M	F				
20	11	33	176	56:96	152	1:4.6
20	7	21	114	18:84	102	1:4.9
25	21	63	252	86:392	578	1:9.2
25	8	23	92	75:149	224	1:9.7
30	18	55	218	258:659	917	1:16.7
30	18	53	210	279:600	897	1:16.6

Influence of host density

The parasite recovery was more when the parasite: host ratio was maintained as 1:4 (20 parasites and 80 hosts). At this ratio, the multiplication rate was seven fold. When the ratio was 1:5.3 the increase in multiplication was 3.5 times. Further increase or decrease of parasite: host ratio reduced the multiplication rate of the parasite (Table 2).

Table 2. Multiplication of the parasite at different host parasite densities

Number of Scales exposed	Parasite: host ratio	Number of parasites recovered			Multiplication rate
		M	F	Total	
20	1 : 1.33	1	0	1	0.07
40	1 : 2.67	12	19	31	2.07
60	1 : 4.00	30	74	104	6.93
80	1 : 5.33	20	33	53	3.53
100	1 : 6.67	6	13	19	1.27

Number of host parasitized

Each female was found to parasitise 7 to 21.5 scale insects under laboratory conditions (Table 3). The mean per cent parasitization observed was 28.7. There was no uniformity in the distribution of the eggs. Within a single waxy coat of the scale insect as many as eleven eggs were found in one case.

Table 3. Percent parasitization of scale insect by *B. bharatiya*

Expt. No.	No. of parasites released	Total No. of scales exposed	No. of scales parasitized	Percent parasitization
1	1 : 2	28	20	28.2
2	1 : 2	91	43	23.7
3	1 : 2	61	17	27.8
4	1 : 2	45	14	31.1
5	1 : 2	46	15	32.6
Mean				28.7

Longevity of the parasite

At room temperature the female parasite lived for 1.3 to 1.5 days, while the male lived for about a day. When reared at different temperatures and with different food materials, significant differences were noticed in the longevity of the parasite (Table 4). Among the temperatures tested, 15°C reduced the longevity significantly. Among the different food materials provided, 100% honey + water increased the adult longevity significantly.

Table 4. Longevity of *B. bharatiya* at different temperatures and with different food materials

Temperature (°C)	Longevity of the parasite fed with different food materials												Over all mean
	Honey + Water			Sugar Crystals + water			Soaked raisins			control			
	M	F	Mean	M	F	Mean	M	F	Mean	M	F	Mean	
30	2.5	3.4	3.0	1.0	1.3	1.1	1.1	1.2	1.1	1.2	1.3	1.2	1.6
25	4.0	4.0	4.0	1.8	2.4	2.1	1.2	1.5	1.5	1.0	1.5	1.3	2.2
20	4.7	4.6	4.7	1.8	2.7	2.3	1.3	1.4	1.3	1.1	1.4	1.3	2.4
15	5.0	5.9	5.5	2.7	3.1	2.9	2.3	2.8	2.5	1.1	1.4	1.3	3.0
10	3.0	3.1	3.0	1.0	1.0	1.0	1.0	1.0	1.0	1.2	1.4	1.3	1.6
Mean	3.9	4.2	4.0	1.7	2.1	1.9	1.4	1.6	1.5	1.1	1.4	1.3	2.2

	CD
Between Temperature	0.12**
Between food	0.12**
Between temperature x food	0.09**
Between temperature x food x sex	0.37**

Fecundity

The fecundity of the parasite was worked out under laboratory conditions. The average fecundity of one female was found to be 36.16 eggs.

Life history

B. bharatiya is a gregarious, bisexual ectoparasite of scale insects. The adults have been found to emerge mostly in the afternoon. Peak parasite emergence is observed

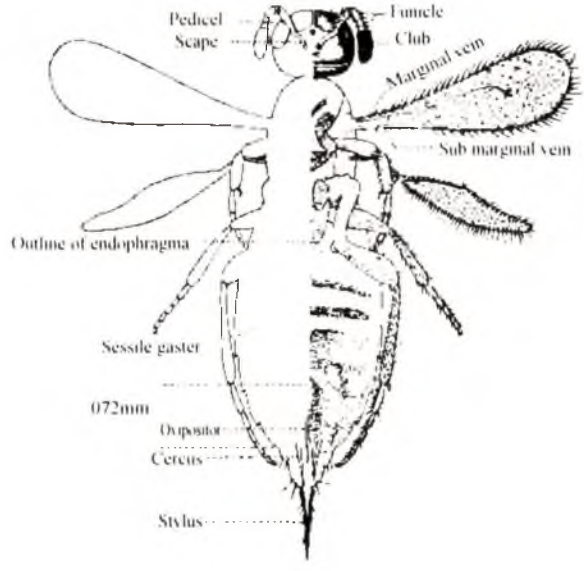


Fig. 1. *Botryoideclava bharatiya* (Subba Rao) adult-female

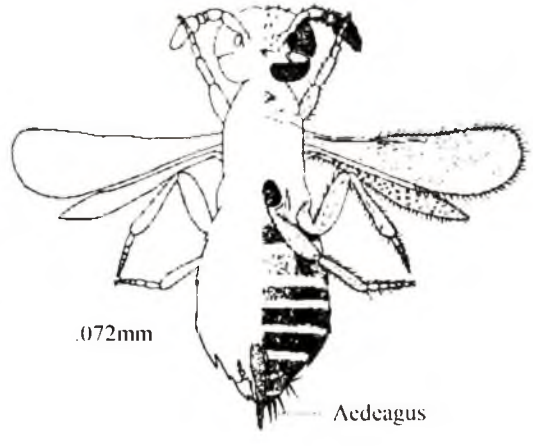


Fig. 2. *Botryoideclava bharatiya* adult-male

between 2 to 3 pm when the room temperature is comparatively high. The parasite emerged by lifting the scaly covering of the host insect. The emerging adult lies on its dorsum. The head followed by the forelegs comes out first. By gripping the forelegs on the rim of the scale, rest of the body is pulled out. Upon emergence the adult grooms its legs, wings and antennae.

Adult behaviour

Soon after emergence the wasp starts actively searching for food, mate and host. Active locomotion is mainly running and flight is rarely resorted to. They are attracted to light.

Sexual behaviour

Under laboratory conditions the premating period lasts for about twenty five minutes. On approaching a female, the male vibrates its wings vigorously and exhibits excited movement. Virgin female responds by ceasing all its activities and allows the male to mount on its dorsum. The male palpitates its antennae over the female antennae and gently taps the female head with its forelegs. The wings of the female are then stretched while those of the male vibrate fast. A receptive female slightly raised its abdomen and remains motionless. The male turns back and feels the change in the position with its antennae. It quickly moves to the rear, lowers its abdomen below that of the female and copulates. During mating, the male holds on to the female by its forelegs and mid–legs, while the hind legs and wings touch the substrate to provide additional support. Mating period lasts for 1 to 4.33 minutes. The males mate repeatedly with a female and under laboratory conditions one male was found to mate three times. In between two matings there was a resting period of about two minutes.

Females are monogamic and mate only with one male at any time of the day. An inseminated female avoids other males. When approached by another male it either resorts to quick running or takes to short flight. Males are polygamous and in one case a male was found to mate with eight females.

Duration of development

Duration of different developmental stages are as follows:

	State	Duration in days
	Egg	5–6
Grub	First instar	3–4
	Second instar	2
	Third instar	2–3
	Prepupa	1
	Pupa	10–11
	Total	23–27

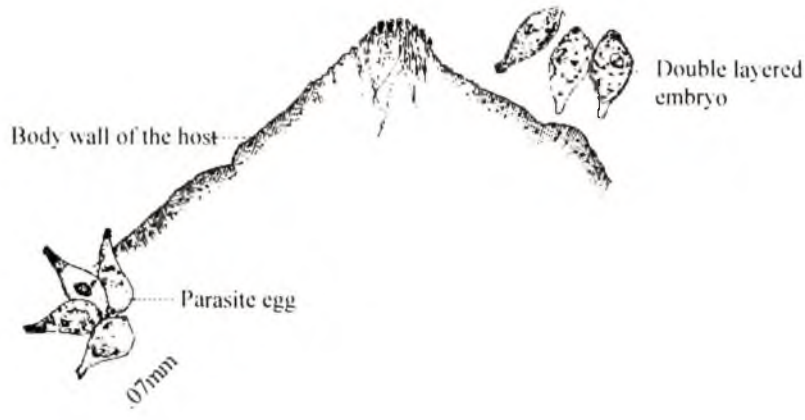
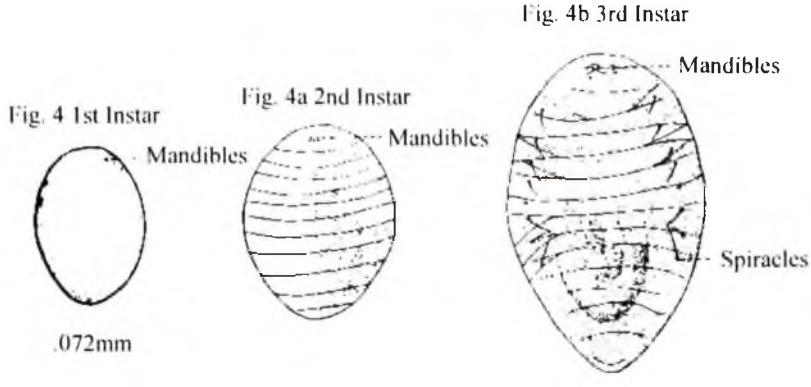


Fig. 3. Egg of *Botryoideclava bharatiya*



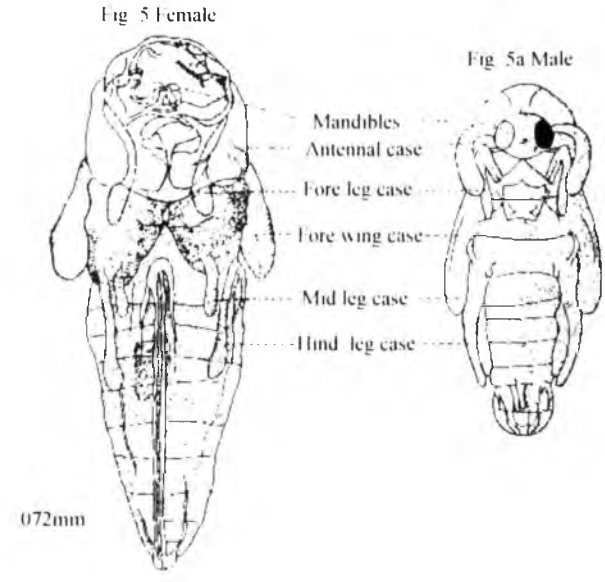
Larvae of *Botryoideclava bharatiya*

Description of different stages

Adult female

Head broader than long (3:2); small brick red eyes set wide apart; 6 segmented geniculate antennae; scape two and a half times longer than pyriform pedicel (5:2); funicle 2 segmented, 0.01 mm long with three hairs/segment; club 2 segmented, 0.08 mm in length, provided with hairs and sensoria; club with sensoria appear like a bunch of grapes under higher magnification. Length of the antenna is 0.16 mm.

Thorax almost smooth, gaster sessile and abdomen longer than thorax (2.5:1.0). Forewings long and narrow (3.75:1) uniformly fumose, speculum absent. Hind wings lanceolate, sharply pointed at apex, long and narrow (7:1), fore, mid and hind legs measure 0.30, 0.43 and 0.32 mm long respectively. Tarsi 5 segmented; tibial spur well developed and long in fore and hind legs. Ovipositor sheath exerted with a shaft



Pupae of *Botryoideclava bharatiya*

and a pair of stylets. Female (Fig. 1) measures 1.301 mm in length and 0.304 mm in breadth and is pale brown to yellowish brown in colour.

Adult male

Male (Fig. 2) is very similar to female except for the absence of sensoria on the club of antennae. Fore wing 0.30 mm long and 0.09 mm broad. Hind wing measures 0.29 mm in length and 0.04 mm in breadth. Fore, mid and hind legs measure 0.24, 0.37 and 0.38 mm in length respectively. Aedeagus large, robust and measures 0.07 mm in length. The adult male measures 0.997 mm in length and 0.249 mm in breadth.

Eggs

The stalked eggs are laid on the ventral surface of the scale insect near the margin of the body. It is double bodied with an egg proper and a bulb, oval in shape and measures 0.18 mm in length and 0.083 mm in breadth (Fig. 3). On hatching the larvae are found aggregated round stylet region of the host. Fragmented chorion is left behind the margin of the host and the period of incubation lasts for 5 to 6 days.

Grub

First instar

Larval instars are characterized by the shape and size of the mandibles. The newly hatched buff coloured larva has pale brown pointed mandibles. The larva measures 0.318 mm in length and 0.221 mm in breadth (Fig. 4). This stage lasts for three to four days.

Second instar

Segmentation clear, mandibles bigger, darker and acutely pointed. Peristaltic movements are clear. The larva measures 0.443 mm and 0.319 mm in length and breadth (Fig. 4a) respectively and this stage lasts for about 2 days.

Third instar

The larva is rounded anteriorly and narrow posteriorly. Cephalisation is distinct. Mandibles are larger with a distinct denticle. As in other final instar hymenopteran larvae there are ten short tracheae dorsolaterally leading to the spiracles. Yellowish digestive tract is visible through the transparent body wall. The fecal matter is eliminated as meconial pellets. The larva measures 0.747 mm and 0.429 in length and breadth (Fig. 4b) respectively and this stage lasts for 2 to 3 days.

Pupa

It is milky white in colour with an elongated caudal end. Feeding ceases at this point and the larva turns and lies on its dorsum with its ventral aspect facing the waxy covering of the scale insect. This stage lasts for 10–11 days. The female pupa measures 1.080 mm and 0.443 mm (Fig.5) and the male 0.762 mm and 0.346 (Fig. 5a) in length and breadth respectively.

Host selection and oviposition

The female parasite runs over the cane piece containing host, palpitating its antennae over the scale surface, hesitating or stopping momentarily at places in between scales. The suitability of the host is examined with the antennae, mouth parts, tarsal, abdominal tip and ovipositor. Once a potential host is encountered, the parasite exhibits a circular movement along the margin of the scale insect and repeatedly probes the scale surface with the antennae. Then it mounts on the dorsum and moves from the centre of the waxy coat to the periphery, testing the suitability of the host with its abdomen.

Penetration site of the ovipositor is near the margin of the waxy covering. The drilling process involves the thrusting of the ovipositor at an angle between the rim of the scale insect and the surface of the cane. The backward thrusting movement of the ovipositor lasts for 1.3 to 3.0 min. The female is not found to feed on the host fluid prior to oviposition.

Discussion

Howard (1895) acknowledged the general importance of the Aphelinidae as natural enemies of armoured scale insects. As early as 1906, Compare recognised the outstanding economic value of a species of *Aphytes* as a natural enemy of the California red scale, *Aonidiella aurantii* (Maskell) in citrus in China. They have excellent searching capacity and are relatively free from hyperparasites.

Several species of Aphelinidae have played a major role in eminently successful biological control projects directed against serious armoured scale insect pests. Introduction of *A. linganensis* into California from China in 1947, against California red scale marked a significant turning point in a long campaign against the serious pest of citrus (Rosen and De Bach, 1979). It is established in Florida with promising initial

results, against the citrus snow scale, *Unaspis citri* (Comstock) Rosen and De Bach (1979). *A. roseni* was introduced into Peru from Uganda in 1970, against the refous scale, *Selenaspidus articulatus* (Morgau) and it has effected complete biological control (Rosen and De Bach, 1979).

Preliminary field release of *B. bharatiya* in areas where it is not occurring naturally showed the establishment of the parasite (our unpublished data). However further studies are needed to determine the possibility of utilizing this parasite in the biological control of *M. glomerata.*

Acknowledgement

The authors are grateful to Dr. K. Mohan Naidu, Director, Sugarcane Breeding Institute, for his encouragement of this work and to ICAR for funding the AP Cess Fund Scheme under which this work was carried out.

References

Easwaramoorthy, S. and M. Shanmugasundaram (1991). Techniques for culturing hymenopterous parasites. In "*Biocontrol technology for sugarcane pest management* (David, H. and S. Easwaramoorthy ed.). Sugarcane Breeding Institute Publ. p. 165–174.

Easwaramoorthy, S. and N. K. Kurup (1986). The scale insect. *Melanaspis glomerata* (Green) In "sugarcane Entomology in India" (David, H. S. Easwaramoorthy and R. Jayanthi eds.) Sug. Cane Breeding Institute Publ. p. 233–258.

Easwaramoorthy, S., N. K. Kurup and H. David (1983) Preliminary studies on the parasite complex of sugarcane scale insect, *Melanaspis glomerata* (G) *Pestol.*, **7**: 5–6.

Easwaramoorthy, S., K. Subadra Bai, N. K. Kurup and H. David (1986). Survey for the indigenous parasite complex of sugarcane scale insect *Melanaspis glomerata* (G). *Bharatiya Sug.*, **12**: 63–66.

Howard, L. O. (1895) Revision of the Aphelininae of North America; a sub–family of hymenopterous parasites of the family Chalcididae. *U. S. Dept. Agric., Div. Entomol. Tech. Ser.* **1**: 44 pp.

Misra, M. P., A. D. Pawar, and A. Anwar (1982) New records of parasites and predators of sugarcane scale insect, *Melanaspis glomerata* (Green) (Hemiptera: Coccidae) from eastern U. P., India. *Co–op. Sug.* **14**: 123–124.

Nageswara Rao, P (1976) Breeding aspects and measures of assessment of incidence of scale insect on sugarcane. *Proc. All India Sem. Sug. Cane scale insect.* Nidadavole. p. 6–9.

Pruthi, G. S. and V. P. Rao (1942) Coccids attacking sugarcane in India. *Indian J. Entomol.* **4**: 87–88.

Raghavendran, R., S. Easwaramoorthy and H. David (1989) Pathologenicity of *Fusarium subglutinans* to sugarcane scale insect *Melanaspis glomerata* (Green). J. Biol. Control. **1**: 118–121.

Rao, V. P. and T. Sankaran (1969) The scale insect of sugarcane. In Pests of sugarcane (Williams, J. R., Metcalfe, J. R., Mungomery, R. W. and Mathes eds). Elsevier Publ. Co. Amsterdam. p. 325–340.

Raghunath, R. A. V. S. and B. H. K. Rao (1980) Studies on the feeding potential of *Chilocorus nigritus* Fabr. (Coccinellidae: Coleoptera) on scale insect *Melanaspis glomerata* (Green) of sugarcane. *Co–op. Sug.* **12**: 191–192.

Rosen, D. and P. De Bach (1979) *Species of Aphytes of the world. (Hymenoptera Aphelinidae)* (Schimitascheck, E. and Spencer, K. A. eds.) Dr. W. Junk B. V. Publishers, The Hague, 801 pp.

Sankaran, T. and A. M. Mahadeva (1974) Biological control trials against sugarcane scale *Melanaspis glomerata* (G.) in Andhra Pradesh. *Indian J. Pl. Prot.* **1**: 17–22.

Seshagiri Rao, C., S. Venkateshwara Rao and B. H. K. Rao (1976) Observations on the biology of *Pharoscymnus horni* Weise, a predator of scale insect. *Proc. All India Sem. Sug. Cane Scale insect* Nidadavole, p. 28–31.

Subba Rao, B. R. (1980) *Boptryoideclava bharatiya* Gen. Et. Sp. Nov. and a new species of *Eriaphytes* Hayat from India (Hymenoptera: Aphelinidae). *Oriental insects.* **14**: 44–47.

Venkateshwara Rao, V (1983) *Studies on the parasite complex of sugarcane scale insect, Melanaspis glomerata* (Green) *(Diaspididae: Hemiptera) in two coastal districts of Andhra Pradesh.* M. Sc. (Ag) Thesis, Tamil Nadu Agric. Univ. Coimbatore.

Entomon 21 (1): 65–75 (1996)

Description of Three New Species of Oriental *Stilbula* Spinola (Hymenoptera: Eucharitidae) with a Key to Indopacific Species

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Abstract: Three new species viz. *Stilbula peethavarna* Narendran sp. nov., *Stilbula lata* Narendran sp. nov. and *Stilbula ashokai* Narendran sp. nov. are described from Oriental Region. A key for the identification of Indo–pacific species is also provided.

Keywords: Eucharitidae, *Stilbula*, new species, key to Indo–pacific species.

Contributions to our knowledge on the taxonomy of *Stilbula* Spinola of the Indopacific region (including Australia and other islands) were made by Westwood (1874), Cameron (1907, 1909), Girault (1915, 1929), Wheeler and Wheeler (1924), Mani (1935), Watanabe (1958), Mani *et al.* (1974) Hedqvist (1978), Narendran (1985, 1986) and Boucek (1988). Boucek (1988) transferred *Stilbula albipennis* Girault, *Stilbula australiana* Girault, *Stilbula bidentata* Girault and *Stilbula pallidiclava* Girault to *Substilbula* Boucek. The same author also transferred *Schizaspidia manipurensis* Clausen (which was earlier transferred in 1978 by Hedqvist to *Stilbula*) to *Ancylotropus* Cameron. In this present paper we describe three species which are new to science, from the Oriental Region. A key for the identification of Indopacific species is also provided.

1. *Stilbula peethavarna* Narendran sp. nov. (Figs. 1–4)

Holotype Female Length 5.04 mm. Head blackish green with metallic refringence; thorax pale brownish yellow with following parts metallic brownish green: a pentagonal anteromedian portion of mesoscutum; an oval spot on each scapula and on each axilla and a small spot on mesosternum. Eyes pale brown with darker spots; median ocellus brownish yellow; hind ocelli brownish red. T1 anteriorly black, remaining parts of gaster pale brownish yellow with darker spots on median line of T3, T4 and T5; petiole pale brownish yellow without any dark band or ring; antennae, mandibles and legs pale brownish yellow with slight metallic tinge anteriorly on coxae.

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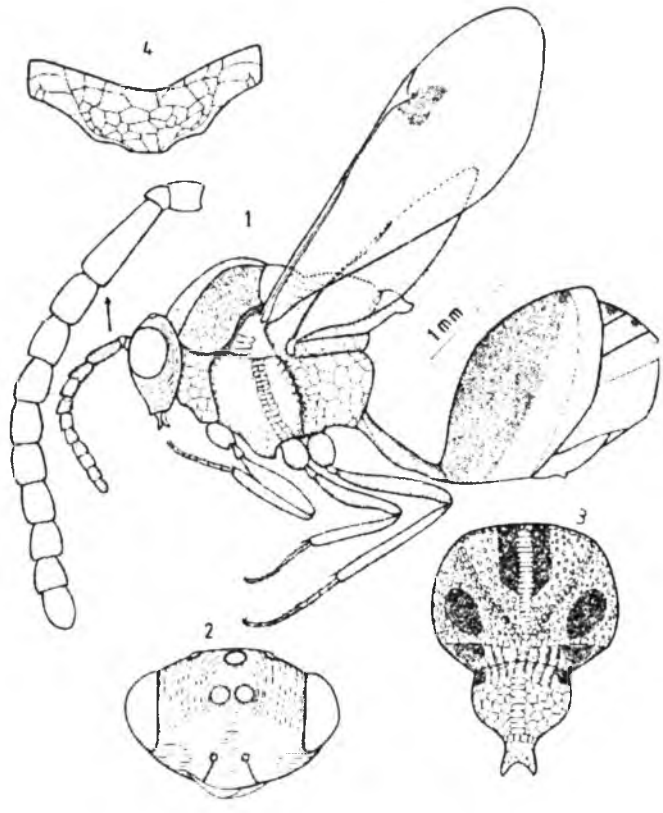
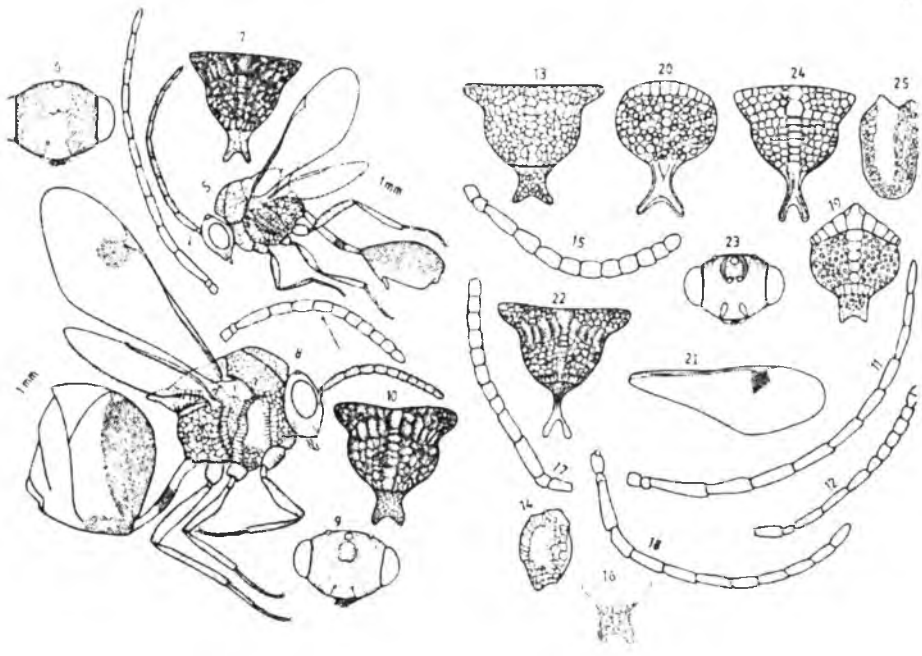


Figs. 1–4. *Stilbula peethavarna* Narendran sp. nov. Female. 1. Side view. 2. Head front view. 3. Thorax dorsal view. 4. Propodeum dorsal view.

Head (Fig. 2) width in anterior view 1.6x its median length (excluding mandibles); mandibles); POL 2.2x OOL; vertex striate; face and frons striate as in figure 2; eyes bare; epistomal sulcus indistinct; clypeogenal sulcus and tentorial pits distinct; mouth plate 8 digitate, these radiating outside over mandibles; gena striate obliquely; malar space 0.7x eye length in profile; eyes separated by 1.8x its height in front view. Antenna 12 segmented, scape not reaching front ocellus; relative proportions of length and width of antennal segments as follows: scape - 12: 10; pedicel = 8:9; F1= 33: 11; F2= 17:11; F3= 15: 11; F4= 15: 11; F5 = 15 : 11; F6= 14: 11; F7= 14: 11; F8 = 12: 11; F9 = 11: 11; F10 = 14 : 11. Length of flagellum 1.8 x length of head in profile.

Thorax with distinct pits on dorsal side, interstices smooth on sides, carinate in middle; SSS transversely carinate; several longitudinal, raised, carinate ridges connect SSS to base of scutellum, enclosing deep foveolate pits in between ridges; scutellum with a median longitudinal fovea containing a median longitudinal row of pits, each pit separated from adjacent one by transverse carinate ridge; scutellum with a single



Figs. 5–7. *Stilbula lata* Narendran sp. nov. Male. 5. Side view. 6. Head front view. 7. Scutellum dorsal view. Figs. 8–11. *Stilbula ashoka* Narendran sp. nov. 8–10. Female. 8. Side view. 9. Head front view. 10. Scutellum dorsal view. 11. Male antenna. Figs. 12–14. *Stilbula pedunculatis* Westwood. 12. Female antenna. 13. Female scuetllum. 14. Male mesopleuron. 15. *Stilbula octodigitata* Girault female antenna. Figs. 16–17. *Stilbula polyrhachiada* Wheeler and Wheeler female. 16. Scutellar horn. 17. Antenna. Figs. 18–19. *Stilbula mysorensis* (Mani and Dubey) female. 18. Antenna. 19. Scutellar horn. 20. *Stilbula atkinsoni* (Mani and Dubey) Female scutellum dorsal view. Figs. 21–23. *Stilbula tanjorensis* (Mani and Dubey) female. 21. Fore wing. 22. Scutellum dorsal view. 23. Head front view. 24. *Stilbula palawanensis* Hedqvist female scutellum. 25. *Stilbula carolinensis* Watanabe female mesopleuron.

narrow horn directed straight posteriorly, widely incised at apex (Fig. 3); mesoscutum slightly depressed in anterior median portion; prosternum with moderately deep alveolate sculpture; mesopleuron and metapleuron sculptures as in figure 1. Median length from SSS to apical tip of scutellar horn 1.3x maximum width of scutellum in dorsal view; fore and hind coxae subequal in length; hind coxa length 1.3x its width. Forewing (Fig. 1) bare, about 3x as long as broad.

Gaster (Fig. 1) laterally compressed forming a median line of ridge on dorsal side except on T1. Petiole a trifle shorter than hind femur and a little less than half length of remaining part of gaster; petiole a little broader at middle.

Female unknown

Host unknown

Holotype Male. Thailand, Locality Unknown; Coll. Unknown. Deposited in Natural History Museum Wien, Austria.

Remarks

The species *Stilbula trimaculata* (Cameron) from Borneo (Kalimantan) resembles this new species in the general appearance but differs from *S. peethavarna* in having forewing without fuscous patch or mark adjoining *St.*; in having gastral petiole longer than remaining part of gaster and in having a triangular bluish and violaceous mark on apex of scutellum. The species *Stilbula quinqueguttata* (Girault) from Australia also resembles this new species in the colour of thorax but differs from *S. peethavarna* in having gastral petiole distinctly longer than remaining part of gaster, petiole white with a fuscous ring distad of middle and in having frons finely and circularly striate.

Etymology The species name is taken from the Sanskrit words. Peetha = yellow, Varna from 'varnum' meaning colour.

2. *Stilbula lata* Narendran sp. nov. (Figs. 5–7)

Holotype Male Length 3.3 mm. Head and thorax bluish green with metallic refringence; interstices of thorax with slight purple reflections; mandibles, ocelli and antenna pale brownish yellow; eye brownish yellow; coxae brown with apices paler; remaining parts of legs pale yellow; distal part of scutellar teeth brown; gastral petiole pale yellow with darker band near middle, remaining part blackish brown with ventral side slightly paler. Wings hyaline, stigma pale brown; *sm* pale yellow.

Head (Fig. 6) width in anterior view 1.6x its median length (excluding mandibles); POL 2.5x OOL; median ocellus separated from occipital margin by less than its own diameter; frons with distinct oblique and semicircular striations (Fig. 6); clypeal area slightly striate and shiny; supraclypeal area smooth and shiny; epistomal suclus faintly distinct; clypeogenal sulci and tentorial pits deep and distinct; vertex and scrobe longitudinally and transversely striate, upper part of scrobe rugosopunctate; mouth plate 12 digitate, these radiating outside over mandibles; gena obliquely striated; eyes separated in front view by 1.8x height of eye. Antenna (Fig. 5) 12 segmented; relative proportions of length: width as follows: scape = 4.5: 4.5; pedicel = 3: 4.5; F1 = 21:4.5; F2 = 15:4.5; F3 = 15:4.5; F4 = 15:4; F5 = 14:4; F6 = 13:4; F7 = 13:4; F8 = 12:4: F9 = 12: 4; F10 = 12: 4.

Thorax with mesoscutum and scutellum deeply and closely punctate, interstices carinate; notauli distinct and alveolate; mesoscutum without a median fovea; SSS carinate; scutellum with a median longitudinal fovea; scutellum wider than distance between SSS and frenal carina; each tooth of posterior scutellar process shorter than stalk of scutellar process which is 1.3x as long as its width (Fig. 7). Propodeum completely punctate, interstices carinate, without median carina, callus bare; mesopleuron (Fig. 5) distinctly and closely punctate without a patch of smooth area; fore and mid coxae mostly smooth and shiny. Forewing (Fig. 5) 2.9x as long as its maximum width, without marginal fringe.

Gaster (Fig. 5) (excluding petiole) 1.9x its height in side view; tergites smooth and polished; petiole smooth, distinctly shorter than remaining part of gaster (41: 33), longer than hind femur (23.5: 33), middle part in dorsal view slightly thickened; gaster (excluding petiole) shorter than thorax (41:46).

Female Unknown

Host Unknown

Holotype Male, India, Kerala, Trichur, Coll. T. C. Narendran, 4.xii. 1988 (Dept. of Zoology, University of Calicut; depository DZCU).

Paratype Male, India, Kerala, Kayamkulam, coll. T. C. Narendran, 19.ii.1989 (DZCU).

Remarks

This new species comes near *Stilbula mysorensis* (Mani and Dubey) in general appearance but *S. mysorensis* differs from this new species in having forewing with slight infumation adjoining *st*, scutellar process blunt and straightly bifurcated (Fig. 19) and eyes separated in front view 1.6x height of eye.

Etymology The species name is just a combination of letters, feminine gender.

3. *Stilbula ashokai* Narendran sp. nov. (Figs. 8–11)

Holotype Female Length 4.1 mm. Head and thorax black with metallic green refringence; antenna yellowish brown with scape, pedicel, last two funicular segments and club paler; mandibles pale yellow; ocelli brown; eyes brown with darkish spots; coxae brown, remaining parts of legs straw yellow; tegulae brown; forewing with brown infumation adjoining stigmal vein; stigma dark brown; *sm* yellowish brown; gastral petiole yellow with pale brown band in middle; gaster yellowish brown with T1 black.

Head (Fig. 9) width in anterior view 1.5x its median length (excluding mandibles); POL 2.5x OOL; median ocellus separated from occipital margin by less than its own diameter; frons with more or less oblique and semicircular striations (Fig.9) extending from ocellar area to supraclypeal and clypeal margins; clypeus and supraclypeal areas smooth; vertex longitudinally striated; scrobe striated on sides, upper part rugosopunctate; mouth plate 14 digitate; gena obliquely striate; malar space in profile 0.6x height of eye; epistomal sulcus indistinct; tentorial pits and clypeogenal sulci distinct and deep; eyes separated by less than 2x height of eye in front view. Antenna (Fig. 8) 12 segmented; relative measurements of the proportions of length: width of segments as follows: scape = 5.5:5; pedicel = 3:5; F1 = 17:5.5; F2 = 11:5; F3 = 10:5.5; F4 = 9:5.5; F5 = 8.5:5.5; F6 = 7.5:6; F7 = 7:6; F8 = 6.5:6; F9 = 6.5:6; F10 = 8:5.

Thorax with mesoscutum and scutellum deeply and closely punctate, interstices carinate; notauli distinct and foveolate; mesoscutum without a median fovea. SSS ecarinate; scutellum wider than the median distance between SSS and carinate frenal groove at base of scutellar process (Fig. 10); width of scutellar stalk subequal to its length (excluding teeth); scutellum with a median longitudinal pitted fovea; mesopleuron (Fig. 8) with a smooth area on anterior half; propodeum completely punctate, interstices carinate, without a median carina, callus bare; fore and mid coxae striate ventrally on sides; hind coxae smooth and shiny. Forewing (Fig. 8) 2.83x as long as its maximum width, without marginal fringe.

Gaster (excluding petiole) shorter than thorax, subglobose and smooth. Petiole smooth, distinctly shorter (45:56) than remaining part of gaster, longer than hind femur (45:38), slightly swollen at middle.

Male

Length 3.43 mm. Similar to female except in following: Antennal segments more elongated (Fig. 11); head width 1.6x its length in front view.

Host Unknown

Holotype Female, India, Kerala, Malampuzha, Coll. T. C. Narendran (DZCU). Paratypes: 2 females and 4 males of same collection data. 1 female, India, Kerala, Sreekaryam, T. C. Narendran, 25. ii. 1989 (DZCU); 2 females, Kerala, Kayamkulam, T. C. Narendran, 21.ii. 1989 (DZCU).

Variations In two paratypes thoracic pleura shows purple tinge in some areas.

Etymology The species is named after the wise King ASHOKA of India.

Remarks

This new species comes near *Stilbula mysorensis*(Mani and Dubey) in general appearance but *S. mysorensis* differs from this new species in having 1) scutellar teeth not diverging and 2) flagellar segments (Fig. 18) not shorter as in the new species (Fig. 8).

Key to Indopacific Species of *Stilbula* Spinola (Hymenoptera: Eucharitidae)

1. Female ..... 2.

– Male ..... 13.

2. Frons completely striated more or less in a circular manner (Figs. 6, 9)..... 3.

– Frons with longitudinal striations mostly on upper half (Figs. 2, 23)..... 12.

3. Petiole with a brownish or blackish ring or band at or near middle, rest of portions pale yellow or white or pale brown..... 4.

– Petiole without a distinct ring or band ..... 9.

4. Petiole coriaceous with a lateral carina, 2.5x longer than wide; scape 3x longer than its width, equal in length of F1; F2 a little longer than wide at apex; F5 to F6 quadrate; F7 wider than long; club as long as scape; general colour aeneous; scape, pedicel, legs (except coxae), femora (except apices), club, distal funicular segments and tegulae pale yellow or yellow; scutellum strongly bidentate at apex but not produced posteriorly, teeth short; mouth plate 4 digitate, Australia

..... *S. quadridigitata* Girault

– Petiole distinctly much longer than above; other characters completely or partly different ..... 5.

5. Antennal scape (Fig 12) 3x longer than pedicel length; posterior horn of scutellum (Fig. 13) short with diverging teeth; mesoscutum with median longitudinal sulcus; general colour of body coppery green; gaster darkish; legs brownish yellow; femora darker medially, Australia..... *S. peduncularis* Westwood.

– Characters not as in above combinations, partly or completely different ..... 6.

6. Petiole 5x longer than wide; scape one–fourth longer than its width (Fig. 15), not quite half length of F1; gaster (excluding petiole) longer than petiole; mesoscutum and scutellum with median sulci; posterior horn of scutellum with teeth shorter than basal stalk; general colour purple; legs except coxae yellowish brown; femora darker; scape concolorous with body; plate of mouth 8 digitate, Australia ..... *S. octodigitata* Girault

– Characters not as in above combination, partly or completely different ..... 7.

7. Scutellar horn (Fig. 16) short, one–third length of scutellum, terminating in two short asymmetrical teeth separated by a distance greater than length of each tooth; petiole less than 1.5x length of remaining part of gaster, 4.3x longer than width of petiole; antenna (Fig. 17) with scape a little less than 2x as long as pedicle; forewing without infuscation adjoining *st*; head and thorax aeneous with antennae and mandibles pale brownish yellow; legs yellow with dark brown hind coxae; gaster (except petiole) dark brown, T1 darker; mouth plate 8 digitate; host: *Polyrhachis dives* F. Smith; Australian

..... *S. polyrhachicida* Wheeler and Wheeler

– Scutellar horn not as above; other characters partly or completely different ..... 8.

8. Scutellar horn (Fig. 19) bluntly and shortly bifurcate; antennal scape (Fig. 18) less than 2x length of pedicel; body black with metallic copper reflections; head black; antenna (Fig. 18) dark brown; forewing with a brown infuscation adjoining *st.*; mouth plate 11 digitate India ..... *S. mysorensis* (Mani and Dubey) Scutellar teeth (Fig. 10) diverging; scape 2x as long as pedicel (Fig. 8); head and thorax green with metallic reflections; antenna yellowish brown with scape, pedicel and last two funicular segments and club pale yellow; forewing with large brown infumation adjoining *st* (Fig. 8); India *S. ashokai* Narendran sp. nov.

9. General body colour black; antenna reddish yellow; coxae concolorous with body; petiole finely punctured; scutellar bifids short, thick; forewing smoky apically; head circularly striate on frons and face; female flagellum 9 segmented, 3 preclaval segments transverse; mouth plate 5 digitate; Australia

..... *S. arenae* Girault

– Characters not in above combination, partly or completely different ..... 10.

10. General body colour purplish; legs (except coxae), petiole, tegulae, scape (except ventrally at base) and pedicel white; forewing lightly infuscated from near bend of *sm*; scutellar teeth of posterior projection longer than basal stalk of posterior process of scutellum; median sulcus of scutellum obscure; petiole about 2x longer than its width, finely and longitudinally grooved, narrowed at base; propodeum with a median ruga; mouth plate 8 digitate; scape a little shorter than F1; gaster deeply punctate on sides and apex of T2; Australia

..... *S. albipetiole* Girault

– Characters not as in above combination, partly or completely different ..... 11.

11. General body colour purple; legs, scape, petiole and gaster brownish yellow; antenna reddish brown; wings clear; base of scutellar process a little longer than wide, longer than teeth; propodeum with a pair of wide median grooves; petiole 3x longer than wide; scape a little shorter than F1; mouth plate 7 digitate; Australia ..... *S. brunneipetiole* (Girault)

– General body colour dark metallic bluish green; head nearly black with blue reflections; antennae brownish black; wings with a diffuse conspicuous infuscation adjoining *st*: coxae concolorous with thorax, rest of legs brown; petiole brownish black to very dark brown; gaster black; scutellar process (Fig. 20) with a 'Y' shaped carina; petiole 0.55x gaster length, smooth, abruptly wider in apical 0.50 part ..... *S. atkinsoni* (Mani and Dubey)

12. Head blue; antenna with basal three segments and apical two segments testaceous; thorax yellowish testaceous with a large blue and violaceous almost semicircular (but longer than wide) mark on basal half of mesoscutum; a smaller oblique mark on each scapula; a line on apex touching scutellum; a smaller triangulate mark on apex of scutellum; petiole without any band or ring of dark colour; scutellar process as wide as long at its base with roundly curved forks which diverge obliquely and as long as basal part; petiole as long as thorax; Borneo (Kalimantan) ..... *S. trimaculata* (Cameron)

– Body black with dark green or bluish reflections; petiole pale brown or pale yellow with a pale brown band in middle (band light coloured in some specimens) scutellar process (Fig. 22) distinctly longer than its basal width; petiole shorter than thorax (including length of scutellar teeth); forewing with brown infuscation adjoining *st*; India (in part) ..... *S. tanjorensis* (Mani and Dubey)

13. Forewing with brown infumation adjoining *st* ..... 14.

– Forewing without brown infumation adjoining *st* ..... 19.

14. Gastral petiole longer than (or equal to) remaining part of gaster ..... 15.

– Gastral petiole distinctly shorter than remaining part of gaster ..... 17.

15. Gastral petiole without a ring of brown or pale brown or black colour; head and thorax blue with dark green reflections, the blue on pleurae with slight violaceous tinge; pronotum without a yellow colour; basal part of scutellar process longer than apical forks which are roundly curved; Borneo (Kalimanthan)

..... *S. leucopoda* (Cameron)

– Gastral petiole with a median brown or pale brown band or ring; other characters partly or completely different ..... 16.

16. General body colour yellowish brown with following parts as follows: head, propodeum (except anterolaterally), metapleuron, mesopleuron (except dorsally), venter of meso and metathorax, coxae, venter of prothorax anterior to coxa, scutellar teeth (except base), a large hive–shaped spot at anterior margin of mesoscutum at meson, reaching middle, an oblique ovate spot a little posterior of middle of each scapula, dark metallic purple with bronze reflections; petiole and legs white, the former broadly ringed with fuscous colour distad of middle; rest of body yellowish brown with dorsum of gaster jet black; scutellum armed with a quadrate stalk which is longer than each teeth; Australia

..... *S. quinqueguttata* (Girault)

– General body colour not as above; head and thorax green with purplish and golden green reflections on thorax; pronotum yellow with a green spot anterior to fore coxae; area of fused prepectus green; legs yellow with basal part of coxae brown; tegula yellow; petiole yellow with brown reflection medially; gaster dorsally dark brown, ventrally yellowish brown; stalk of scutellar process (Fig. 24) longer than teeth; Philippines ..... *S. palawanensis* Hedqvist

17. General body colour pale brownish yellow with following parts as follows: head, a pentagonal area at anterior margin of mesoscutum at meson reaching middle; an oblique ovate spot a little posterior of middle of each scapula, a transverse elliptical spot on each axilla, metallic brownish green; T1 black anteriorly; T3 to T5 with blackish spots on median line (Fig. 1); mouth plate 8 digitate, Thailand ..... *S. peethavarna* Narendran sp. nov.

– General body colour not as above, completely different ..... 18.

18. Frons with longitudinal striations weak and seen mostly on upper half; scutellum with a slender stalk (Fig. 22) diverging into elongated spines; body black with dark green or blue metallic reflections; India

..... (in part) *S. tanjorensis* (Mani and Dubey)

– Frons with longitudinal striations not weak and seen on upper and lower halves of frons (Fig. 9); scutellar process entirely different (Fig. 10)

..... *S. ashokai* Narendran sp. nov.

19. Gastral petiole shorter than remaining part of gaster ..... 20.

– Gastral petiole longer than remaining part of gaster ..... 24.

20. Gastral petiole with dark ring or band medially or submedially ..... 21.

– Gastral petiole of uniform colour ..... 22.

21. Posterior process of scutellum (Fig. 22) with a slender elongated stalk; *st* distinct; mesopleuron with a large smooth area, stalk of scutellar process brown with teeth paler; head and thorax shiny bluish green with a few striations reaching below antennal toruli; mouth plant 8 or 9 digitate; India

..... (in part) *S. tanjorensis* (Mani and Dubey)

– Posterior process of scutellum (Fig. 7) stouter; *st* not as distinct (Fig. 5) as above; mesopleuron rugosopunctate (Fig. 5); stalk of scutellar process and teeth concolorous with thorax which is bluish green; mouth plate 14 digitate; India ..... *S. lata* Narendran sp. nov.

22. Head bare, shiny, frons closely covered with round curved striae which become weaker on lower half; scutellar process thick and broad at base, spines longer than broad, diverging; general body colour green, largely variegated with blue, brassy and purple tints; legs pale brownish yellow; antennae brownish yellow, darker at base and thickly covered with stiff fuscous hairs; mesoscutum with clearly defined furrows; gastral petiole smooth and shiny; Sechelles

..... *S. insularis* Cameron

– Characters not as in above combination, partly or completely different ..... 23.

23. Body generally black with dark metallic green reflections; head black; coxae concolorous with thorax; rest of legs brown; antennae brownish yellow; gaster dark metallic green, terminal segment somewhat brown along margins; head coarsely and umbilicately punctate; antenna with dense pubescence; pedicel short and transverse; forewing with *st* sessile; *pm* very long; scutellar process bidentate, about as long as gastral petiole; India ..... *S. Indica* (Mani)

– Body generally purple; legs except coxae yellowish brown; femora red–brown; gastral petiole concolorous with body; antenna with a conspicuous spicule at apical segment; F1 three times longer than broad, mesoscutum with less distinct shallow median groove than that of scutellum; mouth plate 10 digitate; Australia

..... *S. toga* Girault

24. Gastral petiole white with a median black ring; scutellar process formed (Fig. 13) with teeth subequal in length to basal stalk; mesoscutum with a median longitudinal sulcus; gaster black; mesopleuron with a smooth median portion (Fig. 14); gaster 1.1 to 1.31x as long as petiole; Australia

..... *S. peduncularis* Westwood

– Gastral petiole not as above; other characters partly or completely different ... 25.

25. Head blue, basal 3 segments and apical 2 segments of antenna yellowish brown with the apical ones more rufous than basal ones; thorax yellowish brown with a large blue and violaceous almost semicircular mark (longer than wide) on basal half of central mesoscutum, a similar coloured oblique mark (longer than wide with rounded base) on each scapula, a bluish violaceous line on apex touching scutellum, a bluish violaceous triangular mark on apex of scutellum; mesopleuron smooth with a broad band of stout longitudinal striae at base; Kalimantan (=Borneo)..... *S. trimaculata* (Cameron)

– Head and thorax metallic green, antennae yellowish brown with basal two segments paler; thorax with yellow colour; mesopleuron with a narrow long smooth area (Fig. 25), without a basal band of striae; mouth plate 8 digitate; Caroline Islands ..... *S. carolinensis* Watanabe

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References

Boucek, Z. (1988). *Australasian Chalcidoidea (Hymenoptera).* A biosystematic revision of genera of fourteen families with a reclassification of species. CAB International, London. 832 pp.

Cameron, P. (1907). No. IV. Hymenoptera (Percy Sladen Trust expedition). *Trans. Linn. Soc. Lond.* **12**: 69–86.

Cameron, P. (1909). On two new genera and seven species of Chalcididae (Eucharinae) from Borneo. *Entomologist* **42**: 229–233.

Girault, A. A. (1915). Australian Hymenoptera, Chalcidoidea, VII. *Mem. Qd. Mus.* **4**: 1–365.

Girault, A. A. (1929). Notes on and descriptions of Chalcid wasps in the South Australian Museum. *Trans. R. Soc. S. Aust.* **53**: 309–346.

Hedqvist, K. J. (1978). Some Chalcidoidea collected in the Philippine, Bismarck and Solomon Islands. 2. Eucharitidae, with keys and check–lists to Indo–Australian genera (Insecta, Hymenoptera). *Steenstrupia* **4**: 227–248.

Mani, M. S. (1935). New Indian Chalcidoidea (Parasitic Hymenoptera). *Rec. Indian Mus.* **37**: 241–258.

Mani, M. S., Dubey, O. P., Kaul, B. K. and G. G. Saraswat (1974). Descriptions of some new and new records of some known Chalcidoidea (Hymenoptera) from India. *Mem. School Ent.* **3**: 1–108.

Narendran, T. C. (1985). Family Eucharitidae. 179–182. *In* The Chalcidoidea (Insecta: Hymenoptera) of India and Adjacent countries (Subba Rao, B. R. and Hayat, M. eds.) *Oriental Insects* **19**: 161–310.

Narendran, T. C. (1986). Family Eucharitidae, 51–55. *In* The Chalcidoidea of (Insecta: Hymenoptera) of India and Adjacent countries (Subba Rao, B. R. and Hayat, M., eds.). *Oriental Insects* **20**: 1–430.

Watanabe, C. (1958). Eucharitidae. *Insects of Micronesia* **19**: 19–34.

Westwood, J. O. (1874). *Thesaurus Entomologicus oxoniensis*; or illustrations of new, rare and interesting insects, for the most part contained in the collections presented to the University of Oxford by the Rev. F. W. Hope, M. A., D. C. L., F. R. S. and c. **24**: 1–205. Oxford.

Wheeler, G. C. and E. H. Wheeler (1924). A new species of *Schizaspidia* (Eucharidae) with notes on an eulophid parasite. *Psyche* **31**: 49–56.

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Alpha Systematics of some Eupelmidae (Hymenoptera: Chalcidoidea) from India

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Abstract: Six new species of Eupelmidae viz. *Calosota shyama, Neanastatus reksonus, Australoodera quilonica, Calymmochilus nilamburicus, Hirticauda crisagatra* and *Macroneura nirupama* are described from India and their affinities with related species are discussed.

Keywords: New species, Eupelmidae.

Introduction

Chalcidoidea is an important superfamily of parasitic insects which play a very significant role in preventing the excessive increase of populations in nature of several insect pests of agricultural importance. In spite of this, not much information is available on some families of Indian Chalcidoidea and Eupelmidae is one among them. In continuation of my earlier works on Eupelmidae (Narendran, 1984, Anil and Narendran, 1991, Narendran, 1995) I report and describe six new interesting species of Eupelmidae from India in this paper.

Materials and Methods

The Eupelmids were collected from different localities in Kerala, using a handnet and curated by the methods described by Noyes (1982). The observations were made using M3Z Wild stereozoom (Switzerland made) and Leitz–Wetzlar (German made) microscope. The figures were drawn using the drawing tube of Wild M3Z stereozoom microscope and enlarged using KB enlarger of the model B 2M.

Abbreviations used

DZCU - Department of Zoology, Calicut University
QMB - Queensland Museum, Brisbane, Australia
EL - Eye length
EW - Eye width
F - Female
F1-F7 - Funicular segments 1–7
M - Male
MS - Malar space

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OOL - Ocellocular length
POL - Post–ocellar length
T - Tergite
m - marginal vein
pm - postmarginal vein
sm - submarginal vein
st - stigmal vein

***Calosota shyama* sp. nov. (Figs. 1–6)**

Holotype Female Length 3.49 mm. Black with metallic blue green reflections; ocellar region, parascrobal region, pronotum, mesoscutum, scutellar–axillar complex, callus part of propodeum with metallic green reflections; scape except apex brown; apex of scape, rest of antenna, plical region of propodeum, all coxae, fore femur, fore tibia except base and apex, dark brown; mid femur, mid tibia, hind femur except base and hind tibia, pale brown; tarsi pale while; gaster black with metallic blue reflections.

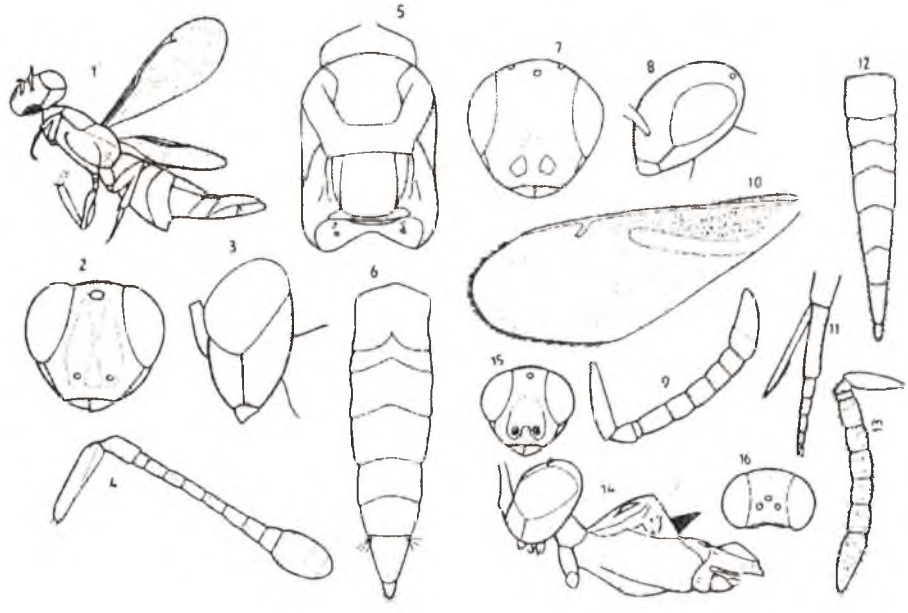
Head (Figs. 2 and 3) wider than its median length (excluding mandibles), in front view 51: 48, with sculpture minutely reticulate; mandibles tridentate; toruli not wide apart; inter–antennal area moderately convex; malar groove distinct, MS:EL–20: 40 in side view; eyes circular; EL: EW – 33: 16 in front view; scrobes deep, channel–like; margins ecarinate; extending to anterior ocellus; parascrobal region flattened. Antenna (Fig. 4) inserted slightly below level of lower margin of eye orbit; scape slightly bent, 0.32 x of rest of antenna; pedicel longer than F1; anellus subquadrate; club subequal to preceding three segments combined, anterior ocellus within scrobal limits, OOL:POL–3: 9; vertex smoothly rounded into occiput.

Thorax (Fig. 1) shorter than gaster, 36: 65 in side view; covered with short white hairs on dorsolateral sides; mesoscutum densely reticulate punctate, wider than long (Fig. 5) with wide shoulder like angle on either side of pronotum and with a shallow depression medially at about half its length; notauli as subparallel lines confined to anterior part of mesoscutum; parapsidal lines short, sublateral band of fine sculpture near anterior edge of each lateral lobe of mesoscutum; scutellar–axillar complex with longitudinal striations; scutellum distinctly convex, quadrangular; axillae linear along sides of scutellum; prepectus extended to base of tegula; mesopleura finely reticulate; metanotum with dorsellum extended over scutellar apex; propodeum with plical region convex, linear, without median carina; propodeal foramen broadly concave, carinate; forewing (Fig. 1) hyaline; *pm* subsequal to *st*; relative measurements of veins *sm: m: pm: st* 2.20:1.55:0.30: 0.30; mid tibial spur short, nearly half as long as basitarsus; hind basitarsus subequal to following three segments combined.

Gaster (Fig. 6) with epipygium elongated, rounded at apex; ovipositor sheath slightly protruding.

Male Unknown

Host Unknown



Figs. 1–6. *Calosota shyama* sp. nov. Female: 1. Body profile. 2. Head front view. 3. Head lateral view. 4. Antenna. 5. Thorax dorsal view. 6. Gaster dorsal view. Figs. 7–13. *Neanastatus reksonus* sp. nov. Female: 7. Head front view. 8. Head lateral view. 9. Antenna. 10. Forewing. 11. Apex of mid tibia and mid tarsus. 12. Gaster dorsal view. 13. Male antenna. Figs. 14–16. *Australoodera quilonica* sp. nov. Female: 14. Body profile. 15. Head front view. 16. Head dorsal view.

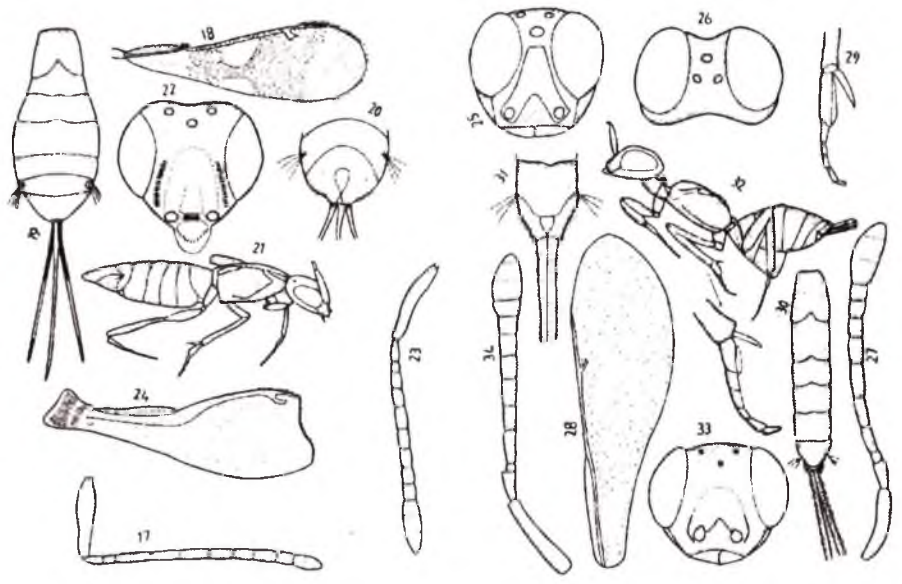
Holotype Female, India: Kerala, Calicut University Campus Narendran. T. C. 10. ix. 1986. DZCU.

Distribution India: Kerala.

Etymology Species name is taken from Sanskrit words 'Shyama' means black colour (feminine gender).

Discussion

Only two species of *Calosota* have been reported from the Oriental Region so far. *C. splendida* Girault from Philippines (Girault, 1927) differs from this species in (i) having body colour brilliant green (in *C. shyama* it is black with metallic blue–green reflection) (ii) *pm* twice longer than *st* (*pm* subequal to *st* in *shyama*) (iii) anellus longer than wide (subquadrate in the new species) and (iv) club equal to F5 (in the new species club subequal to F5–F7 combined). *C. stenogastra* Masi (Masi, 1926) from Taiwan differs from this species in having (i) a transverse furrow across parascrobal region at about dorsal level of interantennal area (here in this new species transverse furrow absent), (ii) scrobe not reaching median ocellus (scrobe reaching median ocellus in *shyama* and (iii) *pm* longer than *st* (*pm* subequal to *st* in *shyama*. *C. sinensis* Ferriere from China also differs from this new species in having (i) pedicel slightly shorter than F1 (distinctly longer than F1 in the new species), (ii) club distinctly shorter than F5–F7 combined (subequal to F5–F7 combined in



Figs. 17–20. *Australoodera quilonica* sp. nov. Female: 17. Antenna. 18. Forewing. 19. Gaster dorsal view. 20. Apex of gaster posterior view. Figs. 21–24. *Calymmochilus nilamburicus* sp. nov. Female: 21. Body profile. 22. Head front view. 23. Antenna. 24. Forewing. Figs. 25–31. *Reikosiella crisagatra* sp. nov. Female: 25. Head front view. 26. Head dorsal view. 27. Antenna. 28. Forewing. 29. Apex of mid tibia and mid tarsus. 30. Gaster dorsal view. 31. Apex of gaster. Figs. 32–34. *Macroneura nirupama* sp. nov. Female: 32. Body profile. 33. Head front view. 34. Antenna.

shyama), (iii) *sm* twice longer than *m* (sm) about 1.4x longer than *m* in *shyama*, (iv) *m* 3x *st m* 5x *st* in *shyama)* and (v) *pm* nearly twice st (pm as long as st in *shyama*).

2. *Neanastatus reksonus* sp. nov.

(Figs. 7–13)

Holotype Female Length 2.38 mm. Black, head orange yellow, except a narrow strip along malar groove; a small patch laterally on vertex posteriorly to eyes; antenna brown; pronotum, median part of mesoscutum yellowish; mandibles red; lateral ocelli black; legs pale yellow (except basal three–fourth of hind femur, hind tibia, apical segment of hind tarsus, brownish black, rest of hind tarsus white).

Head (Figs. 7 and 8) wider than long (excluding mandibles) in front view (60: 55), with umbilicate sculpture on vertex and on frons, finely lineolate on lower face and on malar space; mandibles tridentate; toruli with margins not carinate; malar groove distinct, MS: EL 11 : 34 in side view: EL : EW 36: 13 in front view; scrobe very short, impressed only immediately dorsal to each torulus. Antenna (Fig. 9) inserted below level of lower margin of eye orbit; scape a trifle more than one–third rest of antenna, slightly expanded towards apex, distinctly longer than combined length of pedicel, anellus and F1; anellus less than 3x as wide its length; pedicel shorter than F1; F1 longer than F2; F2 and F3 subequal, F4 slightly longer than wide; F5 wider than long; club 2–segmented, as long as preceding three segments combined; OOL: POL 2:4; vertex very short, separated from occiput by distinct carina.

Thorax faintly sculptured, pronotum large, subtriangular, subequal to mesoscutum, posterior margin lamellate, broadly concave, projecting over mesoscutum; mesoscutum convex laterally, depressed medially; axillae small, widely separated, flat and in same plane as of scutellum; scutellum medially divided by longitudinal sulcus, pointed postero–medially, apex recurved as hook, extended over dorsellum; prepectus large, quadrate, longitudinally striate, posterior margin broad, slightly incised medially, extended to tegula; mesopleura finely lineolate reticulate anteriorly, posterior half longitudinally striate; propodeum with plical region linear, in the form of vertical strip, medially divided, concealed by scutellar apex; macropterous, forewing (Fig. 10) about 2.75x as long as wide, a trifle longer than gaster, hyaline, hairless streak present as in figure 10; *m* longer than *sm; pm* more than 3x *st*; mid tibial spur (Fig. 11) subequal to basal three tarsal segments combined; hind basitarsus slightly shorter than following three segments combined.

Gaster (fig. 12) narrow, more than 1.5x longer than thorax; T1 longer than T2, its posterior margin incised medially; T2–T4 with posterior margins medially concave; T5 with hind margin broadly concave; epipygium narrow, conical, posterior margin rounded; ovipositor sheath slightly exserted.

Male Length 1.85 mm. Differs from female in having conspicuously setose antenna (Fig. 13) and gaster shorter than thorax.

Host Unknown.

Etymology Species name is an arbitrary combination of words.

Holotype Female, India: Kerala, Kayamkulam, T. C. Narendran and Party 21. ii. 1989, DZCU.

Paratypes 2F, 1M, India; Kerala, Kayamkulam, T. C. Narendran and Party, 21. ii. 1989, 1F, India: Kerala, Thavalappara, T. C. Narendran and Party, 26. xi 1988; 3F India; Kerala, Kumarakam, T. C. Narendran and Party, 29, xi. 1988, 1F India: Kerala, Mangode, T. C. Narendran and Party, 27. xi. 1988, 1F India: Kerala, Malampuzha, T. C. Narendran and Party, i. 1986.

Distribution India, Kerala

Discussion

This species is close to *N. indicus* Shafee and both species have hyaline forewings. But in the latter species, the coloration of body is orange yellow (here in this new species it is black with head orange yellow and pronotum and mesoscutum medially yellowish), pedicel and F1–F4 subequal in length (in the new species pedicel is shorter than F1. F1 longer than F2, F2 and F3 subequal and F4 shorter than F3), forewing 2.5x as long as wide (2.75x as long as wide in this new species) and *m* slightly shorter than *sm* (*m* longer than *sm* in this new species). This new species differs from *N. pulchricorpus* (Girault) (Girault, 1914) in having different colour patterns. It differs from all other species such as *N. turneri* Ferriere (Ferriere, 1938), *N. cinctiventris* Girault (Girault, 1913a), and *N. trochantericus* Gahan (Gahan, 1919) in having hyaline forewing (whereas in these above mentioned species forewing is infuscated).

***Australoodera quilonica* sp. nov. (Figs. 14–20)**

Holotype Female Length 2.70 mm. Ovipositor sheath 1.11 mm. Body yellowish brown; scape basally and a small patch ventrally above middle, pedicel, anellus, first funicle segment, club, ovipositor sheath at its basal half and apex, propodeum, prepectus, mesopleura anteriorly, a narrow strip along each mid femur, along each mid tibia, along each hind femur, and along each hind tibia, dark brown; most part of gaster dark brown; rest of antenna yellowish brown; concave part of mososcutum along its middle with green reflections.

Head (Fig. 14–16) finely sculptured, wider than long in front view as 40:35 (excluding mandibles); mandibles tridentate; lower face convex, clothed with sparse, dark, erect hairs; malar groove distinct, MS: EL 10:26 in side view; EL: EW–22: 12 in front view; toruli not wide apart, inter antennal area slightly convex; scrobes short, shallow, lateral margins carinate, gradually merging with frons, not extended to anterior ocellus; parascrobal region reduced. Antenna (Fig. 17) long, inserted below level of lower margin of eye orbit; scape long, slightly expanded just above base, with a thin lamella along ventral margin, 0.32 x of rest of antenna; pedicel slightly longer than half of F1; anellus distinctly longer than wide; F1 longer than F2; F2 and F3 subequal; F4 slightly longer than F5; F5 and F6 subequal; club shorter than preceding two segments combined; OOL: POL–35:70:Vertex with hind margin rounded, bearing dark erect hairs.

Thorax Smooth and shining, slightly longer than gaster; notauli groove–like, delimiting mesoscutum into an anterior subtriangular median lobe and two strongly convex lateral lobes with sharp dorsal margins, interspace between lateral lobes deeply concave; axillae not meeting medially, longitudinally striate; scutellum (Fig. 14) distinctly convex, finely punctate with a tuft of median dark erect hairs; apex of scutellum rounded, prepectus small, subtriangular, not extending to base of tegula; mesopleura with shallow fine sculptures; metanotum short, dorsellum very narrow, hidden by scutellar apex; propodeum with anterior margin medially slightly incised, posterior margin deeply concave; macropterous, forewing (Fig. 18) strongly pubescent, infumated, infumation interrupted by two round hyaline areas opposite each other below *m* at about its middle, *m* longer than *sm; pm* more than 3x *st* relative measurements of veins *sm: pm: st*–4.25: 7.1: 2.8: 0.8; mid tibial spur about half as long as basitarsus; mid–tarsus with single row of spines on either side ventrally, hind basitarsus longer than following two segments combined.

Gaster (Fig. 19) convex; T1 longer than T2, its posterior margin deeply emarginate medially; T2 shorter than T3 with posterior margin slightly emarginate medially; T3 longer than T2; T4 with posterior margin more or less straight; T6 with posterior margin convex; epipygium (Fig. 20) narrow, convex, deeply emarginate medially above ovipositor, the emargination enclosing a subcircular anal sclerite; ovipositor sheath thin, long, 0.85x of gaster.

Male Unknown

Host Unknown

Holotype Female, India: Kerala, Memana (Quilon), T. C. Narendran, 26. ii. 1989. DZCU.

Distribution : India: Kerala.

Discussion

This species is readily distinguished from the two Australian species, viz. *A. varicornis* (Girault) and *A. bicinctipilum*(Girault) (Girault, 1922) in the presence of stiff black haires on the scutellum. The genus *Australoodera* is circumtropical in distribution.

4. *Calymmochilus nilamburicus* sp. nov. (Figs. 21–24)

Holotype female Length 3.65 mm. Body blackish brown, head, thorax, forewing brown; scape, legs, prepectus brownish yellow.

Head (Fig. 22) flattened dorsoventrally, slightly broader than high in dorsal view as 48: 46, broader than thorax as 48 : 37; clypeus strongly protruding, denticulate on front margin, clypeal margin dorsally with another smaller projection, latter strongly carinate, slopes down to join the larger projection, mandibles tridentate, outer tooth long, narrow, inner ones smaller; lower face, just above clypeal margin medially in between toruli convex, with few transverse striations, lower face separated from malar space by distinctly raised, carinate ridge, latter continuous anteriorly with clypeal margin and posteriorly joins inner eye orbit; malar space facing ventrally; MS: EL 13: 29 in side view; eyes elongately oval, EL: EW–29: 15 in front view; scrobes shallow, broadly U–shaped, minutely reticulate, margins ecarinate, not extending to anterior ocellus. Antenna (Fig. 23) inserted right at clypeal margin; scape long, slightly bent at about middle, slightly exceeding front ocellus; pedicel slightly longer than F1; anellus almost as long as wide; F1–F5 longer than wide; F6 and F7 as long as wide; club 3–segmented, as long as preceding 3 segments combined; OOL:POL–7:9; vertex flat, separated from occiput by carina, latter facing ventrally.

Thorax : mesoscutum finely reticulate, broader than long as 22: 18, flat, without notauli and parapsidal lines, lateral margins carinate, abruptly decline, bearing thin lamella; scutellar axillar complex flat, in same plane; axillae faintly demarcated, not meeting anteromedially; scutellum finely reticulate and longitudinally striate, longer than broad as 17: 14, with lateral and posterior margins carinate, apex rounded, metanotum short with dorsellum slightly declined, propodeum short with plical region depressed, declined with a median carina, prepectus short, triangular almost as long as tegula; mesopleura with sculpture reticulate, brachypterous, forewing (fig. 24) reaching base of gaster, its posterior margin slightly concave; mid tibial spur as long as basitarsus, basal three tarsal segments with single row of dark pegs on either side ventrally.

Gaster (fig. 21) elongated, laterally compressed, longer than head and thorax combined; T1-T5 with posterior margins more or less straight; T1 longer than T2 and T3 combined; epipygium longest, broadly conical, straight, rounded at apex: ovipositor sheath not exerted.

Male: Unknown.

Host: Unknown.

Holotype Female, India: Kerala, Nilambur, T. C. Narendran and Party, 1982. DZCU.

Distribution India, Kerala.

Discussion

This forms the first description of a species of *Calymmochilus* Masi from Oriental region. This species resembles the European, *C. dispar* Boucek and Andriescu (Boucek and Andriescu, 1967) in reduced forewing, but the latter species differs in having an anellus which is distinctly longer than wide (anellus almost as long as wide in the new species), gaster almost as long as head and thorax combined (gaster longer in the new species), gastral tergites almost subequal, epipygium bent (T1 longer than T2 and T3 combined, epipygium longest, straight, in the new species), and coloration of the body shiny black with metallic green-violet reflections on lower face (body blackish brown in the new species). It also differs from the type species, *C. atratus* Masi (Masi 1919) and the Australian *C. marksae* Boucek (Boucek, 1988) both of which are fully winged.

5. *Reikosiella (Cupreocauda) crisagatra* sp. nov. (Figs. 25-31)

Holotype Female Length 4.20 mm. Ovipositor sheath 8.97 mm. Body brown, head, pronotum, mesoscutum metallic green mixed with coppery tinge; scrobe posteriorly purple; toruli, scape at base, pronotum antero-medially pale white; callus of propodeum with metallic green tints; ocelli pale yellowish brown; legs pale yellow; ovipositor sheath brownish black; mandible reddish brown.

Head (Figs. 25 and 26) a trifle over 1.1x wider than long in frontal view, cubical in lateral view; lower face above clypeal margin clothed with long, white hairs medially malar groove distinct, malar space with sculpture coriaceous, MS: EL 17:35 in side view; eyes oval; EL:EW–36:23 in front view, frontovertex narrow, minutely, densely, reticulate; interantennal region strongly convex, scrobe densely transversely reticulate, triangular channel-like, deep, lateral margins carinate, ending about one ocellar diameter before median ocellus; parascrobal region very narrow with a row of short, white hairs. Antenna (Fig. 27) inserted below level of lower margin of eye orbit; scape subcylindrical, slightly curved, 0.29 x of rest of antenna; pedicel slightly longer than F1; anellus subquadrate; F1-F3 increasing in length; F6 subquadrate; F7 wider than long; club longer than preceding three segments combined; OOL: POL-5:10; vertex transversely striate, hind margin concave, smoothly rounded into occiput.

Thorax pronotum rectangular, medially deeply divided, mesoscutum densely reticulate, longer than broad as 2.1:0.80, with a very short, convex, median triangular lobe anteriorly and two elongate lateral lobes; interspace between lateral lobes deeply concave; parapsidal lines complete; scutellar axillar complex finely reticulate; axillae almost meeting antero-medially; scutellum slightly convex, rounded at apex; metanotum with dorsellum very narrow; propodeum with plical region broad, with a median carina, anterior margin medially incurved, separated from callus part by plical furrow, posterior margin broadly concave, carinate; spiracles large, circular; prepectus

subrectangular, finely reticulate; tegula longer than prepectus; mesopleura anteriorly reticulate, rest smoothly sculptured; macropterous, forewing (Fig. 28) lightly and evenly infuscated; *pm* 3.8x longer than *st*. Relative measurements of veins *sm: m: pm: st* 6.00:5.50:3.30:0.85; mid tibia with group of brown pegs at apex, its spur (Fig. 29) distinctly shorter than basitarsus; each mid tarsus with single row of brown pegs on either side ventrally on basal three segments; hind basitaraus longer than following three segments combined.

Gaster (Fig. 30) narrow, longer than thorax, T1 longer than T2, its posterior margin medially incised; T2 and T3 subequal with posterior margins medially slightly incised, T6 short, its posterior margin broadly convex; epipygium (Fig. 31) subtriangular, with numerous backwardly directed bristles, margin deeply emarginate medially above ovipositor–sheath, enclosing a round sclerite behind which tergite meet; ovipositor sheath stout, densely hairy, very long, more than twice length of body.

Male Unknown

Host Unknown

Holotype Female, India: Kerala, Calicut University Campus, T. C. Narendran and Party, 1981. DZCU.

Distribution India, Kerala.

Etymology : Species name is from Sanskrit, meaning long and lean body.

Discussion

This species differs from the following Australian species. In *R. compressicauda* (Girault) (Girault, 1915) the ovipositor sheath is as long as gaster and has white tips. In *R. pachyscapha* (Girault) (Girault, 1915) the ovipositor sheath is three–fourth of gaster and scape greatly enlarged. In *R. pax* (Girault) (Girault, 1913b) the ovipositor sheath is slightly longer than gaster, forewing deeply infuscated and scape foliaceously expanded. In *R. muramura* (Girault), (Girault, 1921) the ovipositor sheath is only half of gaster and the forewing infuscated from the bent of *sm* to apex, with two longitudinal streaks. *R. gibsoni* Anil and Narendran (1991) (From India) differs from this species in having ovipositor sheath slender, 1.5x the length of body; forewing hyaline; *sm* shorter than *m, pm* slightly longer than *st*; scrobe shallow, margins not carinate; scape 0.37x of antenna; pedicel shorter than F1; anellus longer than wide, F1 longer than F2.

6. *Macroneura nirupama* Sp. nov. (Figs. 32-34)

Holotype Female : length 2.53 mm. Brownish black; head brownish black with metallic green mixed with purple tints, pronotum posterolaterally, a narrow patch posterolaterally on mesoscutal plate, callus part of propodeum, gaster at its base brownish black with metallic green refringence; scape except apex, mid femur, mid tibia at its base, yellowish brown; rest of antenna, gaster, black; pronotum, mesoscutal plate posteromedially with violaceous tinge; rest of mesoscutal plate chocolate brown; mid femur, mid tibia at middle brown; mid tibia at base, mid tibial spur, mid tarsus

except apical segment, hind tibia at apex, hind tarsus except apical two segments, ovipositor sheath except at base and a narrow patch ventrolaterally towards apex, pale white; tegula white.

Head (Fig. 33) a trifle wider than long in frontal view; lower face finely reticulate with short white hairs; malar grooves distinct; malar space finely reticulate, MS in profile about 3x EL; in front view EL 2.26x EW; inter antennal region convex; toruli wide apart, scrobes slightly deeper, transversely reticulate, margins not carinate, not at all extended to anterior ocellus; parascrobal region broad, reticulate; frontovertex broad, broader than width of eye. Antenna (Fig. 34) inserted below level of lower margin of eye orbit; scape elongated, subcylindrical slightly curved, 0.40x of rest of antenna, as long as F1-F3 combined; pedicel shorter than F1; anellus subquadrate; F1 longer than F2; F2 and F3 subequal; F5 and F6 subequal, subquadrate; F7 a trifle less than 2x wider than long; club shorter than preceding three segments combined; ocelli small; OOL: POL–15:35; vertex with sculpture coriaceous, separated from occiput by broadly incurved carinate margin.

Thorax Pronotum smooth and shining medially; pronotal ridge carinate with short, dark, erect hairs in two tufts para-medially: mesoscutual plate reticulate with a broadly V–shaped antero-medial angulated region with sculpture minutely reticulate punctate, deeply declined postero-medially, smooth and shining, lateral margin of mesoscutal plate carinate, abruptly declined to form conspicuous flange; scutellar axillar complex reticulate punctate; scutellum very narrow anteriorly elongate-oval, slightly convex; axillae elongate, subtriangular, flat, nearly meeting anteromedially, metanotum large, smooth and shining, longer than propodeum; anterior margin deeply incurved medially; propodeum very short; transverse, anterior margin straight, posterior margin broadly concave; prepectus short, smooth, subtriangular; tegula large, subrectangular; mesopleura strongly reticulate anteriorly, longitudinally striate dorsolaterally and ventrolaterally, medially smoothly sculptured, posteriorly elongate-reticulate; brachypterous; forewing hyaline, closely attached to thorax, extending slightly beyond apex of scutellum; mid tibia with few dark pegs at apex in straight row, its spur (Fig. 32) subequal to basitarsus; mid tarsus without dark pegs ventrally; hind basitarsus subequal to following three segments combined.

Gaster (Fig. 32) as long as thorax; T1-T4 with posterior margins medially concave, T1 slightly deeply incurved than rest; T5 broadly exposed, almost completely extending over T6; epipygium with posteriomedial margin deeply emarginate, surrounding a subcircular anal sclerite; ovipositor sheath 0.30x of gaster.

Male Unknown

Host Unknown

Holotype : Female, India; Kerala, Kumarakam, T. C. Narendran and Party, 29.xi. 1988, QMB.

Paratypes : 6F data same as that of holotype; 2F, India; Kerala, CPCRI, Kayamkulam, T. C. Narendran and party, 24.iv.1991 2F, India: Kerala, Elamathukavala, T. C. Narendran and Party, 27. ii. 1989; 1F, India: Kerala, Kulamavu, T. C. Narendran and Party, 1.xii. 1988. 1F. India: Kerala, Chindaki, T. C. Narendran 13.xii. 1988.

Distribution : India: Kerala

Discussion

This species runs to *Macroneura pedatorioides* (Hedqvist) in Hedqvist's (1970) key to species of Ethiopian Region. However in *M. pedatorioides* the pronotal hairs are much longer; forewing extends to base of gaster, pedicel longer than F1, F1 subequal to F2, F7 longer than wide. This new species *(M. nirupama)* differs from *M. pedatoria* Ferriere (Ferriere, 1939), the only known Oriental Species in which the hairs on pronotal ridge are much longer, the midtarsus ventrally with a pair of dark, short pegs at apical joint of basal two segments, the ovipositor sheath 0.38x of gaster, pedicel subequal to than F1 and tegula black.

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References

Anil, K. and Narendran, T. C. (1991) A new Species of *Hirticauda* Boucek (Hymenoptera: Eupelmidae) from India. *Hexapoda* 3: 21-23.

Boucek, Z. and Andriescu, I (1967) Notizen uber die gattung *Calymmochilus* Masi, mit Beschreibungd einer neuen Art aus Sudeuropa (Hymenoptera: Eupelmidae). *Acta ent. Mus. natn.* Paragae 37: 233–238.

Boucek, Z. (1988) Australasian Chalcidoidea (Hymenoptera) A Biosystematic Revision of genera of Fourteen families with a reclassification of species. *CAB International* 832 pp. London.

Ferriere, C. H. (1938) Eupelmidae exotiques (Hymenoptera: Chalcididae) Les generes *Metapelma* Wstw., *Anastatoidea* Gahan et *Neanastatus* Girault. *Annls. Soc. ent. Fr.* 107: 25–72.

Ferriere, C. H. (1939) Chalcid flies attacking noxious beetles in India and New Guinea. *Bull. ent. Res.* 30: 166–167.

Gahan, A. B. (1919) Report of a small collection of Indian Hymenoptera. *Proc. U. S. natn. Mus.* 61: 12–16.

Girault, A. A. (1913a) A few new Chalciodid Hymenoptera from Queensland, Australia. *Bull. Wisc. nat. Hist. Soc.* (n. s.) 11:35–36.

Girault, A. A. (1913b) Diagnoses of new Chalcidoid Hymenoptera from Queensland, Australia. *Arch Naturgesch.* 79. Abt. A. H. 6:90-107.

Girault, A. A. (1914) Some new genera and species of Chalcidoid Hymenoptera of the family Encyrtidae with descriptions of new genera and species. *Mem. Qd. Mus.* 4:1–53.

Girault, A. A(1915) Australian Hymenoptera Chalcidoidea–VII. The family Encyrtidae with descriptions of new genera and species. *Mem. Qd. Mus.* 4: 1–184.

Girault, A. A. (1921) Miscellaneous species of Chalcidoid flies from Australia (Hymenoptera: Chalcididae). *Insector Inscit. Menstr.* 9: 185–191.

Girault, A. A. (1922) New Chalcid flies from Australia. *Entomologist* 55: 205–208.

Girault, A. A. (1927) Four new Chalcid flies from the Philippines. *Philippines. Philipp. J. Sci.* 32: 553.

Hedqvist, K. J. 1970. Hymenoptera (Chalcidoidea); Eupelmidae *S. Afr. Animal Life* 14: 402–444.

Masi, L. (1919) Materiali per una fauna dell' Arcipelago Toscano. XI. Chalcidid del Giglio (Seconda seriel) *Ann. Mus. Civ. Stor. nat. Giacomo Doria* **48**: 277–337.

Narendran, T. C. (1984) Chalcids and Sawflies Associated with Plant Galls. In *Biology of gall Insects* (Ed. T. N. Ananthakrishnan) Oxford and IBH Publishing Co. New Delhi, Bombay and Calcutta, 362 pp.

Narendran, T. C. (1995) Parasitic Hymenoptera. interline publishers (In Press).

Noyes, J. S. (1982) Collecting and preserving Chalcid wasps. *J. Nat. Hist.* 16:315–334.

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Secretory Rhythm of the Median Neurosecretory Cells and its Probable Role in Pupal Eclosion Behaviour in the Castor Semilooper *Achaea janata* Linn. (Lepidoptera: Noctuidae)

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Abstract: The median neurosecretory cells of the brain of fifth instar caterpillar showed a rhythm in their secretory activity. In a newly moulted fifth instar larva, the MNSC contained very little amount of neurosecretion and as time passes the amount stepped up and again reduced at 8 hour intervals. During 64 hour the cells contained maximum quantity of neurosecretion and after that a gradual reduction in the amount was noticed. Probable regulatory mechanisms of pupal eclosion by MNSC is discussed in the light of the above observations.

Keywords: *Achaea janata*, median neurosecretory cell, secretory rhythm, eclosion hormone, pupal eclosion.

Introduction

Biological clocks which can control the daily rhythmicity in several aspects of physiology, behaviour and development are prominent in insects. The neurosecretory cells located in the brain are found to be the controlling centres of the rhythmic activities of the endocrine glands (Brady, 1967). Neurosecretory cell products circulating in the haemolymph can affect a wide variety of metabolic and morphogenetic events (Adiyodi and Nayar, 1966; Marks, 1970; Goldsworthy, 1970; Vincent, 1971; Jalaja *et al.* 1973; Muraleedharan and Prabhu, 1979). Although it was originally thought that eclosion hormone (EH), the 62–amino acid neuropeptide, was used only for adult ecdysis, there are reports that the hormone is used for all post embryonic ecdyses as well in the life history of moths (Copenhaver and Truman, 1986).

In view of the importance of endocrine rhythms affecting insect physiology and development, it was considered worthwhile to study the secretory rhythm of the MNSC of the fifth instar larva upto pre–pupa stage in the Castor semilooper *Achaea janata* to elucidate its probable role in pupal eclosion.

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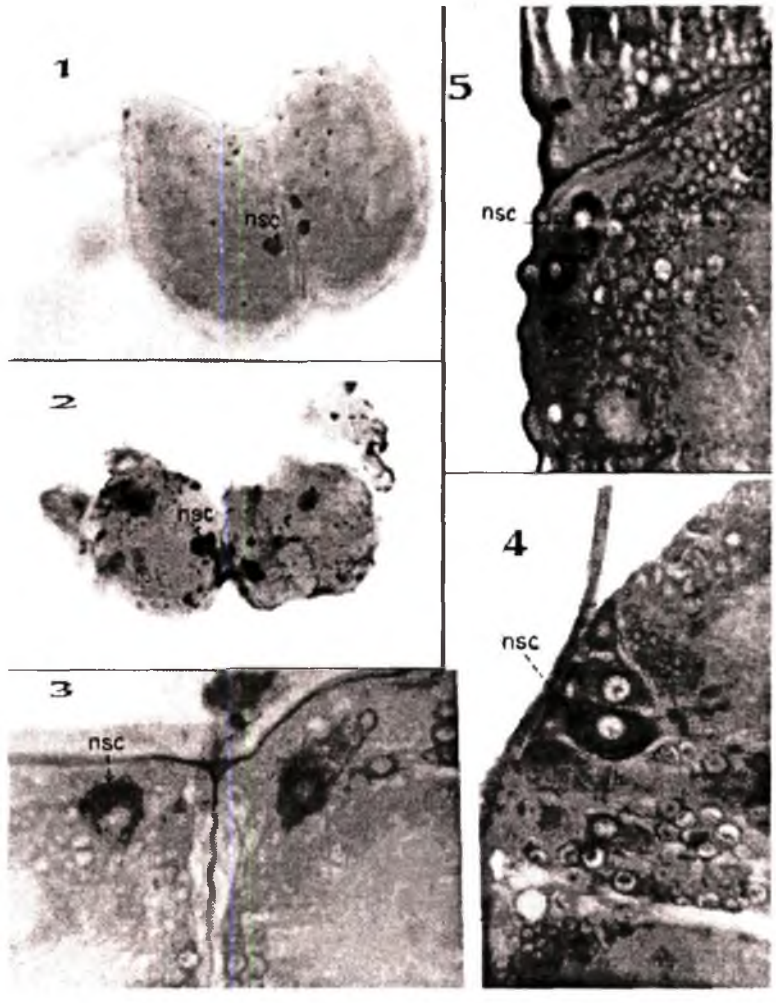

Fig. 1. Whole mount of brain of 5th instar 72hr larva (PAVB×100). Fig. 2. Whole mount of brain 48hr (PAVB×100). Fig. 3. T. S. of brain–24hr. showing MNSC with moderate amount of neurosecretion (CHP×400). Fig. 4. T. S. of brain–64hr. showing maximum amount of neurosecretion in the MNSC (CHP×400). Fig. 5. T. S. of brain–80hr. showing MNSC with minimum amount of neurosecretion (CHP×400).

Materials and Methods

Healthy fifth instar caterpillars of *A. janata* (Lepidoptera: Noctuidae) were selected from the stock colony maintained in our laboratory feeding on fresh castor (*Ricinus communis*) leaves under controlled conditions as described earlier by Annie John and Muraleedharan (1989).

For demonstrating neurosecretory activity of the median neurosecretory cells, Performic Acid victoria Blue (PAVB) technique was employed for whole amounts (Dogra and Tandon, 1964) and Chrome alum Haematoxylin Phloxine (CHP) technique for

Hour	Diameter of the NSC (in μ)	Diameter of the nucleus (in μ)	Neurosecretory index
24	21.18 ± 0.60	11.64 ± 0.74	7 ± 0.71
32	22.58 ± 0.76	12.33 ± 0.74	8 ± 0.03
40	21.88 ± 0.76	9.85 ± 0.60	7 ± 0.36
48	25.34 ± 0.75	13.01 ± 0.61	9 ± 0.33
56	23.28 ± 0.62	10.95 ± 0.60	8 ± 0.36
64	26.71 ± 0.61	13.01 ± 0.61	10 ± 0.35
72	22.58 ± 0.76	8.9 ± 0.74	6 ± 0.36
80	18.47 ± 0.73	7.5 ± 0.60	5 ± 0.18

paraffin sections (Gomori, 1941). Only stained sections were used for all measurements. Diameters of both the MNSC and nuclei in the brain of fifth instar larvae at different time intervals were obtained using a calibrated ocular micrometer attached to the microscope. All values reported are the mean obtained from the values of 5 separate individual larvae. Neurosecretory indices were also calculated as per the method adopted by Jalaja and Prabhu (1977).

Results

A rhythm in the secretory activity of median neurosecretory cells was noticed in the fifth instar larvae, as demonstrated by a change in the secretory index, cell diameter and also in the diameter of the nucleus. In a newly moulted fifth instar larva, the A–cells have very little neurosecretory material. During 24 hour, the histological preparations of NSC showed moderate amount of neurosecretion (Fig. 3). At 32 hour the production of neurosecretion was stepped up, showing an increase in the diameter of the cell. Then at 40 hour neurosecretory content and diameter slightly decreased, then again increased in 8 hour intervals. At 64 hour, maximum quantity of neurosecretion was observed (Fig. 4). Then neurosecretory content gradually decreased and again decreased at 80 hour (Fig. 5).

Discussion

Neurosecretion seemed to affect insectan behaviour and physiology and in many cases a rhythmicity is observed in these processes. Rhythmic cuticular growth has been distributed in several insectan species (Neville, 1970). In *Drosophila*, Rensing (1971) postulated a rhythm of ecdysone release prior to pupariation. In *Acheta domestica* the brain NSC show cyclical changes in RNA and protein synthesis (Dutkowski *et al.* 1971). The synthesis and release of hormones like bursicon, PTTH, calling hormone and eclosion hormone are also found to be rhythmic (Truman, 1978).

Truman and his co–workers have demonstrated that adult eclosion, pupal eclosion, larval and embryonic ecdyses all can be induced by eclosion hormone (Truman *et al.* 1980). Copenhaver and Truman (1986) identified a set of five paired lateral neurosecretory cells in the brain that released EH at adult eclosion. However in earlier ecdyses, EH depletion is seen from the proctodeal nerves of the ventral nervous system. Two pairs of ventro medial NSC represent a novel neurosecretory system and a second set of brain EH cells in Lepidoptera (Truman and Copenhaver, 1989).

In the present study, the median neurosecretory cells show rhythmic secretion of material and the quantity of neurosecretion is found maximum during 64 hour, the beginning of the pre pupal stage and then gradually decreases. According to Highnam (1961), the amount of material contained in a neurosecretory cell at any time depends upon both its rate of synthesis and rate of discharge. In a neurosecretory system containing small amounts of material, the material is discharged as soon as it is formed and the system as a whole is active. In the light of findings and literature cited above, it seems reasonable to assume that the neurosecretory product synthesised in the MNSC may be transported *via* the axons to the neurohaemal organs for their timely release into the haemolymph which inevitably causes the changes associated with puparium formation. This implicates that the median neurosecretory cell products may have a role in pupal eclosion behaviour in *Achaea janata*.

References

Adiyodi, K. G. and Nayar, K. K: Haemolymph proteins and reproduction in *Periplaneta americana*, Curr. Sci., **35**: 587–588 (1966).

Annie John and Muraleedharan, D. Biology and Morphometrics of castor semilooper *Achaea janata* Linn. (Lepidoptera: Noctuidae). Uttar Pradesh J. Zool. **9, 48** (1989).

Brady, J: Control of circadian rhythm of activity in the cockroach I. Role of the corpora cardiaca, brain and stress. J. Exp. Biol. **47**, 155–163 (1967).

Copenhaver, P. F. and Truman, J. W: Identification of the cerebral NSC that contain EH in the moth *M. sexta*. J. Neuro Sci. **6**, 1783–1747 (1986).

Dogra, G. S. and Tandon, B. K: Adaptation of certain histological techniques for *in situ* demonstration of neuroendocrine system of insects and other animals. J. Micro. Sci. **105**, 455–466 (1964).

Dutkowski, A. B., Cymborowski, B. and Przelecka, A: Circadian changes in the ultra structure of the NSC of the pars intercerebralis of house cricket. J. Insect Physiol. **17**: 1763–1772 (1971).

Goldsworthy, G. L: The action of hyperglycaemic factors from the corpus cardiacum of *Locusta migratoria* on glycogen phosphorylase. Gen. Comp. Endocr. **14**, 78–85 (1970).

Gomori, G: Observation with differential stains of human islets of Langerhans. Am. J. Pathol. **17**, 395–405 (1941).

Highnam, K. C: The histology of the neurosecretory system of the adult female desert locust, *Schistocerca gregaria*. Quart. J. Micro. Sci. **102**, 27–38 (1961).

Jalaja, M., Muraleedharan, D. and Prabhu, V. K. K: Effect of extirpation of median NSC on reproduction in the female red cotton bug, *Dysdercus cingulatus*. J. Inspect Physiol. **19**, 29–36 (1973).

Jalaja, M. and Prabhu, V. K. K: Endocrine control of vitellogenesis in the red cotton bug, *D. cingulatus* Fabr. (Heteroptera: Pyrrhocoridae) Entomon 2, 17–29 (1977).

Marks, E. P: The action of hormones in insect cell and organ culture. Gen. Comp. Endocrinol. **15**, 289–302 (1970).

Muraleedharan, D. and Prabhu, V. K. K: Role of median NSC in the secretion of protease and invertase in the red cotton bug, *D. cingulatus*. J. Insect. Physiol. **25**, 237–240 (1979).

Neville, A. C: Cuticle ultrastructure in relation to the whole insect. Symp. R. Ent. Soc. Lond. **5**, 17–39 (1970).

Rensing, L: In: Biochronometry, Menaker, M. (ed.) National Academy Science Press, Washington: 527–539 (1971).

Reynolds, S. E. and Truman, J. W: Eclosion hormone. In: Neurohormonal Technique in Insects (Ed. Miller, T. A.) Springer, New York, 196–215 (1980).

Truman, J. W: Physiology of insect ecdysis I. The eclosion behaviour of saturniid moths and its hormonal release. J. Exp. Biol. **54**, 805–814 (1971).

Truman, J. W: Physiology of insect ecdysis II. The assay and occurrence of the eclosion hormone in the Chinese Oak Silk moth, *Antheraea pernyi*. Biol. Bull. Mar. Biol. Lab Woods Hole **144**, 200–211 (1973).

Truman, J. W: Rhythmic control over endocrine activity in insects. In: Comparative Endocrinology (ed.) P. J. Galliard and H. H. Boer (New York: Elsevier/North Holland Press) 123–136 (1978).

Truman, J. W. and Copenhaver, P. F: The larval eclosion hormone neurons in *M. sexta*: Identification of the brain proctodeal neurosecretory system. J. Exp. Biol. **147**, 457–470 (1989).

Truman, J. W., Taghert, P. H. and Reynolds, S. E: Physiology of pupal ecdysis in the tobacco horn worm, *M. sexta*. I. Evidence for control by eclosion hormone. J. Exp. Biol. **88**, 327–337 (1980).

Vincent, J. F. V: Effects of bursicon on Cuticular properties in *Locusta migratoria migratoriodes*, J. Insect Physiol. **18**, 757–780 (1971).

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BRIEF COMMUNICATION

Some New Records of Fruit Flies (Diptera–Tephritidae) from the Andaman and Nicobar Islands

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Abstract: During the survey between December, 1990 and May, 1993 eleven species of Dacine fruit flies were recorded. Among them five are new records for India and two appear to be new to science.

Keywords: *Bactrocera, Bactrocera (Bactrocera)* sp near *dorsalis*– (A), *Bactrocera (B) albistrigata, Bactrocera (B)* sp. near *fulvipes*, quarantine.

Dacine fruit flies of the genus *Bactrocera* Macquart (Diptera–Tephritidae) includes economically important species attacking a wide range of fruits and vegetables. So far 35 species under the genus *Bactrocera* has been recorded from India (Agarwal, 1988), which includes a lone endemic representative, *Bactrocera (B) andamanesis* (Kapoor), from the Andaman Islands (Kapoor, 1971). Except this, there has been no information available on fruit flies of Andaman and Nicobar Islands. To fill the lacuna a survey was initiated and this note includes the result of the initial part of ongoing survey (December 1990 to May 1993).

Table 1. Fruit flies recorded from Andaman and Nicobar Islands

	SPECIES	REARED HOSTS	DISTRIBUTION
	1	2	3
1.	*Bactrocera* (Zeugodacus) *cucurbitae* (Coquillett)	Cultivated cucurbits, *Mukia maderaspatana* (L) Roem (Cucurbitaceae)	Wide spread over Andaman & Nicobar Islands
2.	*Bactrocera* (Z) *tau* (Walker) L.	*Cucumis sativus* (Cucurbitaceae)	South, Middle & North Andaman, Car Nicobar
3.	*Bactrocera* (*Paradacus*) sp. (near *fulvipes* (Perkins))	Bottle gourd (*Lagenaria siceraria* (Molina) Standley, *Luffa acutangula* (L) Roxb., *Luffa aegyptiaca* Miller (Cucurbitaceae), *Strychnos andamanensis* Hill (Loganiaceae) (New records)	South Andaman

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4.	*Bactrocera* (*Bactrocera*) sp. near *dorsalis (A)*	Rose apple (*Syzygium jambos* (L) Alston, (A)Watery rose apple *S. aqueum*(Burman Alston), Malay apple (*S. malaccense*) (L) Merr. & Perry. *S. samarangense* (Blume) Merr. & Perry, Guava (*P.sidium guajava* L Myrtaceae), Mango (*Mangifera indica* L), *paramygnya andamanica* (King) Tanaka (Rutaceae), *Dryptis longifolia* (Bl.) Pax. & Hoffm. (Euphorbiaceae) *Manilkara littoralis* (Kurz), *Mimusops elengi* L., *Planchonella longipetiolatum* (King & Prail) X J. Lam. (Sapotaceae) *Artocarpus gomeziana* Wall ex.trec., *Artocarpus* sp. (Moraceae). (New records)	South Middle and North Andaman.
5.	*Bactrocera* (*B) albistrigata* (de Meijere)	Guava (*Psidium guajava* L Myrtaceae), *Terminalia procera* Roxb. (Combretaceae), *Neisosperma oppositifolium* (Lam.) Fosb. and Sach. (=*Ochrosia oppositifolia*) (Lam) K. Schum) (Apocynaceae). (New Records)	Car Nicobar and Great Nicobar
6.	*Bactrocera* (Paratridacus) *expandens* (Walker)	*Garcinia andamanica* King (Guttiferae)	South, Middle and Little Andaman.
7.	*Bactrocera* (*B*) *limbifera* (Bezzi)	*Dracontomelon dao* (Blanco) Merri. & Rolfe (Anacardiaceae)	South Andaman
8.	*Bactrocera* (*B*) *andamanensis* (Kapoor)	Collected in Cue lure trap	South Andaman
9.	*Bactrocera* (*B*) sp. (dorsalis complex)	Collected in Cue lure trap	South, Middle and North Andaman
10.	*Bactrocera* (*B*) sp. nov ? 1	*Spondias pinnata* (L. F.) Kurz (Anacardiaceae)	South Andaman
11.	*Bactrocera* (*B*) sp. nov ? 2	*Strychnos andamanensis* Hill (Loganiaceae)	South Andaman

Survey was made mainly in South Andaman with few visits to North, Middle and Little Andaman, Nicobar and Great Nicobar Islands. Fruit flies were collected (1) by rearing infested host fruits (cultivated and uncultivated) in the laboratory and (2) by deploying attractant (Methyl eugenol and Cue lure) baited Steiner traps. Totally 11 species of *Bactrocera* were collected. Two of them are probably new to science (Hancock, Pers. Communication). Details on their hosts and distribution are presented in the Table 1. *Bactrocera (B)* sp. near *dorsalis (A)*, *Bactrocera (B) albistrigata* and *B. (Paradacus)* sp. near *fulvipes* could be interesting in the point of quarantine as these pest species are not recorded so far from the Indian main land.

Acknowledgement

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hosts, Mr. Ramani and Mr. B. S. Bhumannavar, N. C. I. P. M., Bangalore for their help.

References

Agarwal, M. L. (1988). The genus *Dacus* Fabricius (Diptera Tephritidae) in India. *Proc. 1st Int. Sym. Fruit Flies in Tropics* Kuala Lumpur, Malaysia, pp. 191–203.

Kapoor, V. C. 1971. Four new species of fruit flies (Tephritidae) from India. *Oriental Insects* 5(4): 477–482.

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BRIEF COMMUNICATION

New Record and a New species of *Hennedyella* Forsius (Hymenoptera: Tenthredinidae: Allantinae) from India

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Abstract: With an addition of a new species, a monotypic genus *Hennedyella* Forsius is reported from India. Described and illustrated as new species is *H. typica*. Some of the key characters which clearly distinguish it from the already reported species *i.e.*, *H. athaloides* Forsius are given under diagnostic combinations and also under the key to the species.

Keywords: *Hennedyella* Forsius, New record, Hymenoptera, India.

Hennedyella was erected by Forsius in 1935 on the basis of single female specimen, *H. athaloides* Forsius. This unique type specimen was present in Gribodo's collection in the Museo Civico di Genova labelled 'Pulu Lant, Borneo' but, according to Forsius, really from Burma (Benson, 1962).

Because of limited generic characters based on a single specimen the present species does not properly fit into the available description of *Hennedyella*. So, to accommodate this species in this genus some of the generic characters are made slightly broad based. These include antenna 18–19 segmented, scape and pedicel as long as broad or longer than broad. Vein M joins Sc+R at or slightly before the origin of Rs+M. The types of this new species are presently in collection of the authors, but these will be deposited at IARI, Pusa National Collections, New Delhi, when this work is published.

Abbreviations

IATS = Inner apical tibial spur, ICD = Intercenchri distance, IDMO = Interocular distance at the level of median ocellus, ITD = Intertegular distance, LID = Lower interocular distance, MB = Metabasitarsus, OATS = Outer apical tibial spur, OCL = Ocello occipital line, OOL = Oculo ocellar line, POL = Postocellar line.

Key to the species of Hennedyella Forsius

1. Antenna 18 segmented; hypopygium entire behind; sawsheath only as long as metabasitarsus; mesonotum black except on the sloping sides and sutures more or less; front half of stigma black ..... *athaloides* Forsius

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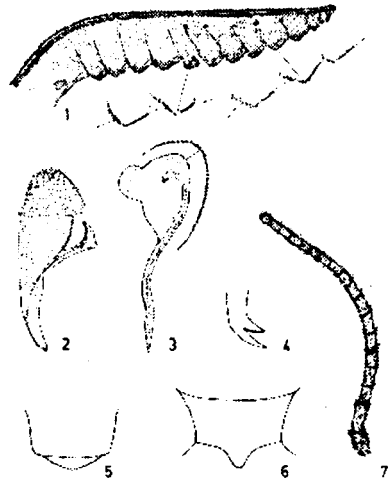

Figs. 1–7. *Hennedyella typica* sp. nov. 1. Lancet. 2. Gonoforceps. 3. Penis valve. 4. Tarsal claw. 5. Clypeus and labrum. 6. Hypopygium. 7. Antenna.

– Antenna 19 segmented; hypopygium produced behind; sawsheath longer than metabasitarsus; mesonotum entirely auratus; stigma entirely black ..... *typica* sp. nov.

Hennedyella typica sp. nov. (Figs. 1–7)

Female Colour: Body auratus, black are: antenna; head above clypeus; mandible apex; metanotum more or less; propodeum; extreme anterior border of tergite 2; apex of saw sheath; extreme apices of femora, tibiae and tarsi of hind four legs. Protibia and tarsi brownish. Wings infumated more strongly at basal 1/3; venation including costa, subcosta and stigma black.

Structure: Average length 7 mm. Antenna (Fig. 7) 19 segmented; scape and pedicel as long as their apical widths; segment 3 longer than 4 as 4: 3; clypeus (Fig. 5) truncate with rounded anterior margin; malar space 0.75x diameter of median ocellus; lower margin of eye below the level of antennal socket; LID:IDMO:EL = 6:9:5; postgenal carina absent; hindorbit not carinated; frontal area almost at the level of eyes; supraantennal pit indistinct; supraclypeal pit well developed; median fovea in the form of a pit in its anterior half and posteriorly only shallowly reaching median ocellus; post-inter and circumocellar furrows indistinct; lateral furrows shallow, streak–like and abruptly ending well before the hypothetical hind margin of head; postocellar area flat, broader than long as 3:2; head narrowing behind eyes; OOL: POL: OCL = 6: 4: 5; mesoscutellum flat; appendage not carinate; ICD: ITD = 1:5; tarsal claw (Fig. 4) with a subapical tooth shorter than apical one, basal lobe absent; metabasitarsus distinctly shorter than the following joints combined as 1:2; saw sheath longer than metabasitarsus as 4:3; IATS: MB: OATS = 3:6:2. Lancet (Fig. 1) having 12 serrulae. Hypopygium (Fig. 6) conically produced posteriorly.

Sculpture and pubescence: Head impunctate, surface subshining; thorax impunctate, smooth and shining with general oily lustre; abdomen impunctate, shining. Body covered with golden pubescence except for the blackish parts where it appears to be silvery.

Male Average length 6 mm. Similar to female except: median fovea with a shallow pit in its anterior half and first cubital cross vein obliterate. Genitalia: Penis valve (Fig. 3); gonoforceps (Fig. 2).

Material examined

Holotype: Female, Uttar Pradesh, Kalamunitop, 2700m, 18. vi. 1993. Paratypes: Male, Uttar Pradesh, Kalamunitop, 2700m, 24.vi.1991. 1 male, 5 females, Arunachal Pradesh, Lazu, 2200m, 6.v.1994.

Population variation

Not observed

Distribution

India: Uttar Pradesh, Arunachal Pradesh

Diagnosis

H. typica is unique in having propodeum entirely black; antenna 19 segmented; saw sheath longer than metabasitarsus; venation entirely black; hypopygium posteriorly produced; mesonotum entirely auratus; supraantennal pit indistinct and saw sheath longer than metabasitarsus. On the combination of these significant characters this species deserves the status of species novum and stands far apart from *H. athaloides* Forsius.

Etymology

The species name is after the typical characters which differentiate it from the already known species of this genus.

Acknowledgement

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References

Benson, R. B. (1962) A revision of the Athaliini (Hymenoptera: Tenthredinidae). *Bull. Br. Mus. Nat. Hist. (Ent.)*, **2**: 333–382.

Forsius, R. (1935) Uber eine neue Selandriinen Gattung mit vielgliedrigen Fuhlern. *Notul. ent. Helsingfors*, **15**: 57–59.

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BRIEF COMMUNICATION

Ascogregarina cheopisi sp. n. (Protozoa, Apicomplexa) from the Flea *Xynopsylla cheopis*

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Abstract: *Ascogregarina cheopisi* sp. n. (Protozoa, Apicomplexa, Eugregarinia, Lecudinidae) is described from the flea *X. cheopis* (Roths.) from Beed district, Maharashtra state, India. Its gamonts were found in the intestine, gametocysts and oocysts in the Malpighian tubules of the adult flea. The gamonts average 20 x 8 μm, the gametocyst 150 um in diameter. This is the first report of the occurrence of *Ascogregarina* species from fleas.

Keywords: new species, Xynopsylla, Ascogregarina

During an entomological investigation of plague–like epidemic in Beed district, Maharashtra state of India, which occurred between September, and December, 1994, a number of small mammals were caught for sero–survey and fleas infesting them were dissected and stained to determine the presence of plague bacillus. During this study we came across a gregarine parasite in some of the rat fleas.

Gregarine parasites of the genus *Ascogregarina (=Ascocystis)* (Levine, 1977 and Ward, Levine, and Craig, Jr., 1982) are known to occur in the insects. So far, members of this genus have only been recorded from mosquito and sandfly spp., Levine, (1977), Lien and Levine (1980), Mourya and Dhanda (1981), Munstermann and Levine (1983).

This communication describes a new species under the genus *Apicomplexa* from the flea *Xynopsylla cheopis*.

Fleas, *Xynopsylla cheopis*, were collected from the host *Rattus rattus rufescens,*, which were caught in Beed district. They were dissected and screened for *Yersina pestis* and other parasites. Gregarine parasites were seen in three fleas out of 18 dissected. The slides with fleas containing gregarine parasite were mounted in Canada balsam and deposited in the museum of this Institute.

Ascogregarina checopisi sp. nov. fig 1 and 2

Description Mature gamonts were seen in the intestine of adult fleas (fig 1), they are elongated, with rounded ends, no psudosegmentation seen. Nucleus was located in the anterior end of the body. Gamonts are filled with clear spherical granules. Mature

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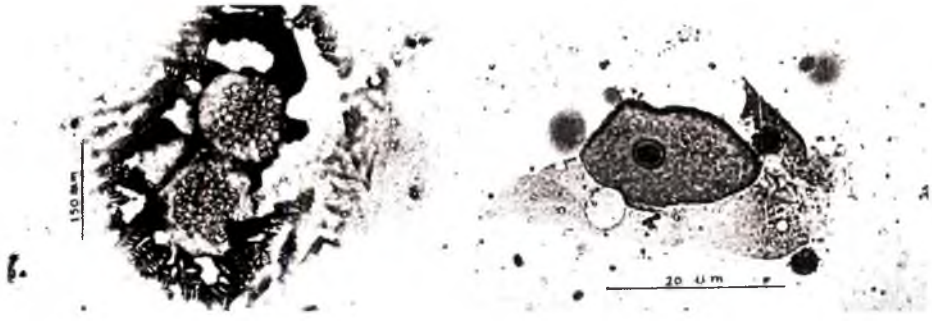

Fig. 1. Mature gamont of *Ascogregarina cheopisi* from alimentary canal of flea *Xynopsylla cheopis*. Fig. 2. Mature gametocysts of *Ascogregarina cheopisi* from the Malpighian tubes of flea *Xynopsylla cheopis*. There are several oocysts in each gametocysts.

gamonts are of the size 20 um in length and 8 um in width. Syzygy was not seen since no larval stages of the fleas collected from the rat burrows. Gametocysts were seen in the malpighian tubules of adult fleas, which were spherical with clear wall (fig 2). Mature gametocyst were 150 um in diameter, with many (serveral hundred) oocysts. Oocysts were oval in shape.

This species is grossly different from all the other gregarine parasites so far known form other insects. The gamonts of this species are comparatively very small in size (20 um) as compared to those of other parasites (varying from 150 to 200 um). Oocysts of this species are oval shaped while in other species they are spindle shaped.

A few specimens (8) of the fleas *X. astia* were also dissected to see the presence of this parasite but none showed any gregarine parasite. In the study area *X. cheopis* was predominant species and a very few *X. astia* were available for examination.

References

Levine, N. D. (1977) Revision and check list of the species (Other than *Lecudina*) of the Aseptate Gregarine Family Lecudinidae *J. Prozool.*, **24**, 41–52.

Ward, R. A., Levine, N. D. and Craig, Jr., G. B. (1982) *Ascogregarina* nom. nov. for *Ascocystis* Grasse, 1953 (Apicomplexa, Eugregarinorida) *J. Parasitol.*, **68**, 331.

Lien, 'S. M. and Levine, N. D. (1980) Three new species of Ascocystis (Apicomplexa: Lecudinidae) *J. Protozool.*, **27**: 147–151.

Mourya, D. T. and Dhanda, V. (1981) Studies on *Lankesteria* sp. (Eugregarinida: Diplocystidae) parasitizing *Aedes albopictus* (Skuse). *Indian J. Parasitol.*, **5**, 119–123.

Munstermann, L. E. and Levine, N. D. (1983) *Ascogregarina geniculati* sp. n. (Protozoa, Apicomplexa) from the mosquito *Aedes geniculatus*. *J. Parasitol.*, **69**, 769–772.

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BRIEF COMMUNICATION

Two New Species of the Genus *Malaconothrus* (Acari: Oribatei) from Tripura, India

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Abstract: Two new species *viz., Malaconothrus rostropilosus* and *M. dipankari* collectd from Tripura, India are described and illustrated.

Keywords: *Malaconothrus* Oribatei, Soil mite.

During faunistic surveys on soil oribatid mites in south district of Tripura, two new species, belonging to the genus *Malaconothrus* Berlese, 1904 were collected and these are described in the present paper. Subias and Sarkar (1982) described 2 new species of genus *Malaconothrus viz., M. pauciareolatus* and *M. crassisetosus* from western districts of Tripura. The types of the new species are deposited in the National Zoological Collection at Zoological Survey of India, Calcutta. All the measurements given in the text are in microns.

Malaconothrus rostropilosus sp. nov. (Figs. 1–2).

Colour of body and legs light brown. Body length 351, width 160.

Prodorsum: Prodorsum broadly triangular, punctate, covered by secretion consisting of minute granules. Rostral setae short (23), nearly half of their mutual distance (37), pilose, clavate shaped. Lamellar setae thin, long (28), tip pointed. Chitinous thick lamellar ridge on either side of prodorsum form a broad translamella. Light polygonal reticular markings and punctation present in area between lamellar ridges. A thick dark line connects lamellar ridges posteriorly. Dark pock marks below transverse ridge. Interlamellar setae similar to lamellar setae, shorter (30) than their mutual distance. Exobothridial setae inserted lateral to interlamellar setae.

Notogaster: Notogaster subcylindrical, punctate with two longitudinal ridges that converge at posterior one fourth and ultimately unite to form a single median ridge, which joins a slightly arched transverse ridge above setal bases of ps_1. Two oblique

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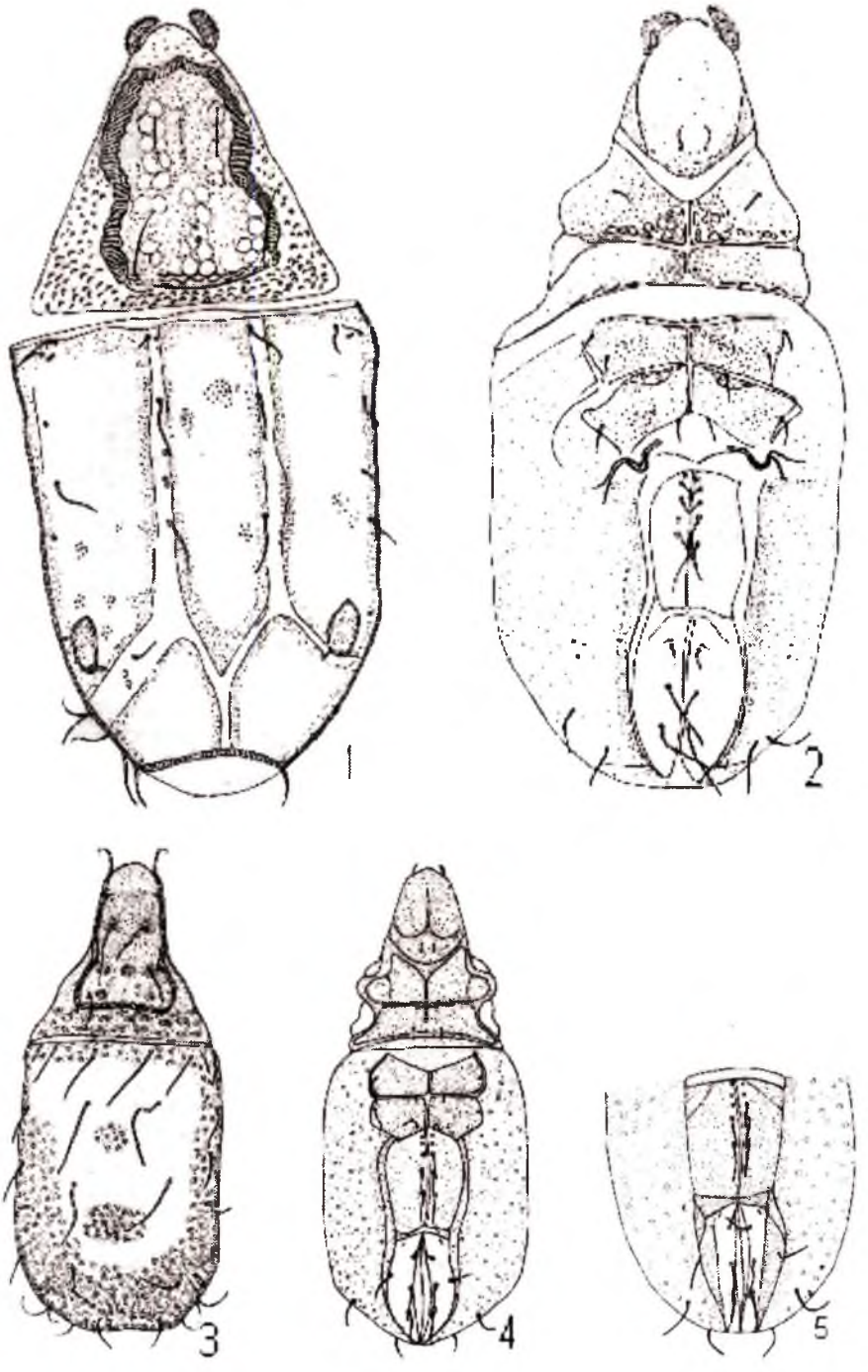

Fig. 1. *Malaconothrus rostropilosus* sp. nov.–Dorsal view. Fig. 2. *Malaconothrus rostropilosus* sp. nov.–Ventral view. Fig. 3. *Malaconothrus dipankari* sp. nov.–Dorsal view. Fig. 4. *Malaconothrus dipankari* sp. nov.–Ventral view. Fig. 5. *Malaconothrus dipankari* sp. nov.–Ano-genital region.

ridges also originate from two longitudinal ridges and proceed towards margins. Notogastral setae 15 pairs, thin, smooth and long but of different sizes. Setae c_1, d_1, e_1, h_1 centrodorsal, c_3, c_p, d_2, e_2, f_2 marginal and h_2, h_3, ps_1, ps_2, ps_3 posterolateral. Two notogastral fissures *ia* and *ip* discernible. A punctate double lined oval area near fissure *ip*.

Ventral Region: All epimeres complete with a gap between epimera II and III, epimeral setal formula 3–1–3–3. Epimeral plates punctated with some markings. Genital plate (133) with 5 pairs of setae, 4 anterior pairs with same mutual distance. An undulating chitinous ridge just above anterior part of genital plate. Genital setae smooth, transparent. Ano–adanal plate (29) without anal setae and with 3 pairs of adanal setae. Adanal setae smooth, transparent, ad_1 (13) and ad_2 (12) longer than ad_3. An oblique slit *iad* located above insertion of ad_3. Surrounding area of ano–genital plate punctated.

Legs: Legs monodactylous, claws strong, sickle–shaped.

Types: Adult female in spirit, India: Tripura: Totabari: Jarjonmura: 29.1.1992, ex. soil with decomposed leaves, Coll. D. Saha. One female paratype in spirit. Collection data same as the holotype.

Diagnosis: All the known *Malaconothrus* species can be broadly divided into two groups *viz.*, one with translamella and the other without it. The former includes species like *M. translamellatus* Hammer, 1958; *M. robustus* Hammer, 1958; *M. peruensis* Hammer, 1961; *M. indifferens* Hammer, 1966; *M. hexosetosus* Hammer, 1971; *M. robustus asiaticus* Aoki, 1967 and the latter group includes species like *M. atuelanus* Hammer, 1958; *M. conicus* Hammer, 1958; *M. pulcher* Hammer, 1961; *M. keriensis* Hammer, 1966; *M. zealandicus* Hammer, 1966; *M. veriosetosus* Hammer, 1971; *M. guninus* Hammer, 1972; *M. pachypilus* Hemmer, 1972 and *M. cornutus* Hammer, 1973. The present species falls in the former group in which no species closely resembles the new species except the species like *M. robustus* Hammer, 1958 and *M. robustus asiaticus* Aoki, 1967 which resemble it to some extent, specially by the presence of typical notogastral markings, body punctation and shape of notogastral setae. The new species, can however be, distinguished from them by the presence of pilose rostral setae, prodorsal markings, more prominant double lined notogastral markings, two oval markings along the fissure *ip*.

Malaconothrus dipankari sp. nov. (Figs. 3 to 5)

Colour of body and legs light yellowish brown. Average body length 404 (range 413–432), average width 169 (range 169-188).

Prodorsum: Prodorsum rounded. Rostral setae smooth, thin, length (21) shorter than their mutual distance (35). Lamellae almost parallel for their whole length, area between them covered by finely anterior tips of lamellar ridges, distal ends of lamella also connected by a thick transverse ridge. Lamellar setae fine, smooth, long(35), extend beyond anterior transverse ridge. Interlamellar setae (26) shorter than their mutual distance. Exopseudostigmatic setae minute. The neck region below the posterior transverse ridge finely punctated with some polygonal markings.

Notogaster: Sides of notogaster parallel, anterior border straight, shoulder corners rounded, posterior end rounded. Notogastral setae 15 pairs, smooth, long (21–68), fine. Chitinisation of basal part of few anterior notogastral setae becomes light and looks like a ring. Setae c_1, d_1, e_1, h_1 centrodorsal, c_3, c_p, d_2, e_2, f_2 marginal, ps_1, h_2, h_3 postero-lateral. Six of them *viz.*, c_1, d_1, and e_1 are however considerably longer, approximately as long as the distance between hairs d_1 and e_1. the mutual distance c_1–c_1 (42), d_1–d_1 (47), e_1–e_1 (70), h_1–h_1 *(84)* and c_2–c_2 (108). Body densely foveolated and with minute punctation. Foveolation in marginal part denser than middle part. In some specimens foveolation very light. Body without any prominent ridges except two thin lines parallel to lariffisure *ip*.

Ventral Region: Genital setae 5 pairs, 4 anterior ones with same mutual distance, posterior ones displaced twice this distance. All genital setae smooth and transparent. No anal setae. Adanal setae 3 pairs, smooth, transparent. ad_3 shorter than ad_1 and ad_2. Ventral surface foveolated and finely punctated. All epimers complete with a gap between epimera II and III. Epimeral setal formula 3–1–3–3.

Legs: Legs monodactylous, claws strong, sickle–shaped.

Types: Adult female in spirit, India: Tripura: Patichari: 5 kms south of Karbook; 4.III. 1992, ex. soil beside paddy field. Coll. D. Saha. One female paratype in spirit. Collection data same as the holotype. Two female paratypes in spirit, India: Tripura: Monaipara: Almora; 4.III. 1992, ex. humus below banana plant. Coll. D. Saha.

Diagnosis: The new species *M. dipankari* resembles *M. dorsofoveolatus* described by Hammer, 1979 from Java regarding shape of the body, presence of notogastral foveolae and shape of the notogastral setae. But the Indian specimens from Tripura clearly differs from *M. dorsofoveolatus* in having foveolae and punctation covering the whole notogastral surface, rostral setae shorter than their mutual distance, thick and prominent posterior transverse ridge connecting the distal ends of lamellae, polygonal markings on the distal part of prodorsum and longer notogastral setae. The new species is dedicated after the name of the collector of the holo and paratypes.

Acknowledgement

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References

Aoki, Jun–Ichi (1967) Oribatiden (Acarina) Thailand. *Nature and life in South East Asia*, **5**, 189–192.

Berlese, A. (1904) Acari nuovi, Manipulus III. *Redia*, **2**, 10–32.

Hammer, M. (1958) Investigations on the Oribatid fauna of the Andes mountains. The Argentina and Bolibia. *Biol. Skr. Dan. Vid. Selsk.*, **10(1)**, 30.

Hammer M. (1961) Investigations on the Oribatid fauna of the Andes mountains, Peru. *Biol. Skr. Dan. Vid. Selsk.*, **13(1)**, 19–20.

Hammer, M. (1966) Investigations on the Oribatid fauna of New Zealand. *Biol. skr. Dan. Vid. Selsk.*, **15** (2), 23.

Hammer, M. (1971) On some Oribatids from Viti Levu, the Fiji Islands. *Det. Kon. Dan. Vid. Selsk.*, **16** (6), 8–9.

Hammer, M. (1972) Investigation on the Oribatid fauna of Tahiti, and on some Oribatids found on the Atoll Rangiroa. *Det. Kon, Dan. Vid. Selsk.*, **19** (3), 20–21.

Hammer, M. (1973) Oribatids from Tongatapu and Eua, the Tonga Islands, and from Upolu, Western Samoa. *Det. Kan. Dan. Vid, Selsk.*, **20** (3), 15–16.

Hammer, M. (1979) Investigations on the Oribatid fauna of Java. *Biol. Skr. Dan. Vid. Selsk.*, **22**, 9.

Subias, Luis Santos and Sadhana Sarkar (1982) New representatives of Nothroides Oribatids (Acarida) from India (Thrypochthoniidae and Malaconothridae). *Redia* **LXV**, 39–49.

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BRIEF COMMUNICATION

Record of hyperparasitoids on exotic parasitoid *Leptomastix dactylopii* How. parasitizing citrus mealybug *Planococcus citri* (Risso) in India

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Citrus mealybug *Planococcus citri* (Risso) was successfully kept under control in citrus orchards through inoculative releases of an exotic parasitoid *Leptomastix dactylopii* How. (Hym., Encyrtidae) around Bangalore and other places wherever releases were effected (Krishnamoorthy and Singh, 1987). The parasitoid got established on *P. citri* attacking different fruit crops in the region (Krishnamoorthy and Mani, 1989; Krishnamoorthy, 1990).

During our regular studies on the recover of *L. dactylopii* four hyper parasitoids were reared for the first time from *L. dactylopii* parasitised mealybugs. They were determined as *Promuscidea unfasciativentris* Girault, *Marietta leopardina* (Motshulsky) (Hym., Aphelinidae), *Prochiloneurus indicus* (Shafee, Alam and Agarwall) (Hym., Encyrtidae) and *Aprostocetus* (= *Tetrastichur purpureus* (Cam.) (Hym., Eulophidae).

In India, *P. unfasciativentris* was not only reported as a hyperparasitoid of *Anagyrus pseudococci* Grlpt. (Avasthi and Shafee, 1978) but also found as a primary parasitoid of *P. citri.* Similarly, Meyerdirk *et al.* (1978) have also recorded *Prochiloneurus dactylopii* (How.) from *L. dactylopii* and *Anagyrus* sp. in Texas. Species of both *Marietta* and *Aprostocetus* are generally regarded as hyper parasitoids. In the present study the level of hyperparasitism by these hyperparasitoids was between 3 and 6% during summer months.

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References

Avasthi, R. K. and S. A. Shafee (1978). *Cerococcus hibisci* Green (Homoptera: Asterolecaniidae) and its chalcid parasites. *J. Bombay Nat. Hist. Soc.*, **74**: 374–376.

Krishnamoorthy, A. (1990). Evaluation of permanent establishment of *Leptomastix dactylopii* against citrus mealybug in India. *Fruits*, **44**: 45–29–32.

Krishnamoorthy, A. and S. P. Singh (1987). Biological control of citrus mealybug with an introduced parasite, *Leptomastix dactylopii* in India. *Entomophaga*, **32**: 143–148.

Krishnamoorthy, A. and M. Mani (1989). Recovery of an exotic parasitoid *Leptomastix dactylopii* from *Planococcus citri* infesting some Horticultural crops. *J. Biol. Control*, **3**: 125.

Meyerdirk, D. E., W. G. Hart and H. A. Dean (1978). Two newly established primary parasites *Leptomastix dactylopii* How. and *Anagyrus* sp. found attacking *Planococcus citri* (Risso) in Texas. *South Western Entomologist*, **3**: 295–298.

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BRIEF COMMUNICATION

Two New Rhyncaphytoptid Mites (Acari: Eriophyoidea) From West Bengal, India

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Abstract: Two new species viz. *Pseudodiptacus caseariasis* and *Diptilomiopus indicus* infesting *Casearia tomentosa* and *Ficus sp.* respectively are described from West Bengal, India.
Keywords: Acarina, eriophyids, new species, West Bengal, India

***Pseudodiptacus caseariasis* sp. nov. (Figs. 1–7)**

Female: Body 149(126–154)μm long, 60(34–61)μm wide, robust, fusiform, yellowish in colour. Rostrum 51(40–57)μm long; curved down; subapical seta 8(8–9)μm long. Shield more or less oval, 41(28–41)μm wide, anterior lobe absent; shield design represents network of cells, median line present on 0.5 part of rear shield; admedian present on 0.65 part of shield; with a tier of 13 cells extending along anterolateral shield margin; 8 cells occur on the middle shield and 2 cells present on rear shield; dorsal tubercles ahead of rear shield margin, 35(31–35)μm apart; seta short 2.8 μm long, directing up. Foreleg from base of trochanter 37(37–48)μm long; femur 11(11–14)μm long, and without seta; patella 3(3–5)μm long, without seta; tarsus 9(9–11)μm long and 2 upper setae each 28(28–30)μm long, 1 lower seta 6 μm long; claw 6(6–8)μm long; featherclaw divided 9–rayed. Hindleg 35(24–38)μm long from base of trochanter; femur 11 (10–11)μm long; patella 3(2–3)μm long without seta; tibia 3(3–4)μm long without seta; tarsus 7(7–11)μm long and seta 32(27–32)μm long; claw 6(6–7)μm long. Anterior coxa separated; sternal line absent; first coxal tubercles and seta absent; second coxal seta 23 μm long; third coxal seta 45 μm long; both fore and hind coxae are smooth; second tubercles at the base of fore coxae and a little ahead of third tubercles.

Opisthosoma with 62(62–70) tergites and 91(82–92) microtuberculate sternites; dorsal thanosome with a mid dorsal ridge; microtubercles more or less round and located on sternite margin; lateral tubercles absent; first ventral seta 9(8–10)μm long on sternite 34(33–34); second ventral seta 5(4–6)μm long on sternite 54(54–57); third ventral seta 37(27–39)μm long and on sternite 14(13–14) from rear end; caudal seta 57(51–67)μm long; accessory seta absent; genitalia 22(18–24)μm long, 23(23–28)μm wide; genital coverflap smooth; genital seta 6(6–7)μm long.

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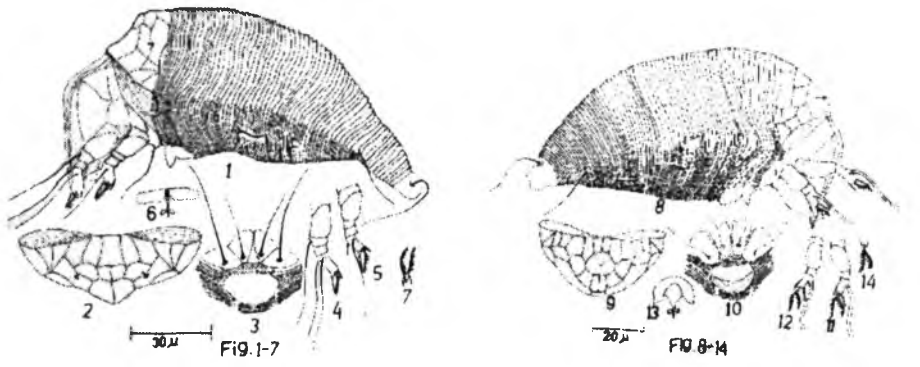

Figs. 1–7. *Pseudodiptacus casearíasis* sp. nov. female. 1. Lateral view of mite. 2. Dorsal shield. 3. Coxae with female genitalia. 4. Fore-leg. 5. Hind leg. 6. Internal female apodeme. 7. Feather claw. Figs. 8–14. *Diptilomiopus indicus* sp. nov. female. 8. Lateral view of mite. 9. Dorsal shield. 10. Coxae with female genitalia. 11. Fore-leg. 12. Hind leg. 13. Internal female apodeme. 14. Feather claw.

Male: Not seen.

Type material: Holotype: Female (marked), on slide (No. 1181/19/92), India, West Bengal; North 24–Parganas; Madra 21.v.1992 from *Casearia tomentosa* Roxb. (Samydaceae), coll. R. K. Pandit. **Paratype**: 4 females on slides bearing the holotype and 42 females on 4 slides (Nos. 1182–1185/19/92). Collection data as in holotype.

Relation with the host: The mite is vagrant on lower surface of leaf. Due to infestation leaf curling on ridge is seen.

Remarks

The genus *Pseudodiptacus* Chakrabarti *et al.* (1992) is known by only two species. The present new species differs from *P. combrestis* (Ghosh and Chakrabarti, 1982) in having separated smooth coxae, non-microtuberculate tergites, 9–rayed featherclaw besides shield design. It is also distinct from *P. litseae* Chakrabarti, Ghosh and B. Das, 1992 in having median line on 0.5 posterior part of shield, smooth coverflap, tergites and coxae.

2. *Diptilomiopus indicus* sp. nov. (Figs. 8–14)

Female: Body 136(112–136)μm long, 67(56–67) wide; robust, fusiform yellowish in colour. Rostrum curved down just perpendicular to the body; 41(35–41)μm long; subapical seta 6–7 μm long. Shield 26(20.5–26)μm long, 60(60–70)μm wide, suboval; shield design represents a clear network; median line present except central cell; admedian line present on 0.3 part of anterior and posterior portion of shield; anteriorly a row of 14 cells and 2 anterolateral cells present; 13 cells including the central cell occur on the middle shield and one cell present on rear shield; dorsal tubercles and setae absent. Foreleg 26(25–27)μm long from base of trochanter; patella fused with femur, 12–13 μm long, seta absent; tibia 3(2–3)μm long, without seta; tarsus 6.5 (5.6–6.5)μm long; two upper setae, each 26(26–30)μm long and a short lower

seta, 5.6μm long; claw 6.5 μm long, knobbed; featherclaw 7–rayed. Hindleg 23(22–23)μm long from base of trochanter, patella fused with femur 11(11–12)μm long; tarsal seta 22(22–27)μm long; other characters as in foreleg. Fore coxae separated; both coxae almost without any ornamentation; first coxal tubercules absent; second coxal tubercles much ahead of the level of third coxal tubercles.

Opisthosoma with 61(61–79) tergites and 81(81–92) sternites, an indistinct dorsal ridge extends from rear shield margin upto 0.75 part of thanosome posteriorly; microtubercles present on sternites; lateral seta absent; first ventral seta 13(12–13)μm long, on sternite 32(30–32); second ventral seta 9.3(7.3–9.3)μm long, on sternite 49(45–50); third ventral seta 24(24–26)μm long, on sternite 11(10–13) from rear; accessory seta absent; caudal seta 30(27–30)μm long; genitalia 13(12–14)μm long and 26(24–26)μm wide; coverflap granular distally; genital seta 5.6(5.6–6.5)μm.

Male: Not seen.

Type material: Holotype: Female (marked), on slide (No. 1186/3/92), India: West Bengal: Jalpaiguri, Kuttimari, 16.v.1992 from *Ficus sp.* (Moraceae), coll. R. K. Pandit. Paratypes: 6 females on the slide bearing the holotype and 22 females on 2 slides (Nos. 1187–1188/3/92). Collection data as in holotype.

Relation to host: This species inhabits on the undersurface of leaves. No damage symptom is seen.

Remarks

This genus is so far known by 16 species including 13 species from India (Chakrabarti, *et al.* 1992) *Dipltilomiopus inducus* sp. nov. closely relates to *D. cocculae* Mohanasundram, (1981); *D. ficusis* Chakrabarti and Mondal (1983) and *D. holoptellus* Chakrabarti and Mondal (1983) by having 7–rayed featherclaw, fused patella, knobbed claw and absence of accessory setae. However, the present new species can be easily separated from the above three species by its distinct shield design, having thanosomal ridge and distally granular coverflap. *D. cuminis* Chakrabarti *et al.* 1992 and *D. camerae* Mohanasundram (1981) and present new species are also related with regard to similar antero–lateral shield design and smooth tergites but in the former two species shield with dorsal tubercles, fatherclaw 6–rayed and coxae ornamented.

All the type materials are presently deposited in the collection of Biosystematics Research Unit, Department of Zoology, University of Kalyani.

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References

Chakrabarti, S. and Mondal, S., 1983. An account of the genus *Diptilomiopus* Nalepa (Acarina: Eriophyoidea) from India with description of three new species and key to the Indian species. Acarologia, **24** (3): 299–307.

Chakrabarti, S., Ghosh, B. and Das, B., 1992. New genera and species of Rhyncaphytoptidae (Eriophyoidea) with key to subfamilies and genera. Acarologia, **33** (1): 75–84.

Ghosh, B. and Chakrabarti, S. 1982. A new genus and three new species of eriophyid mites (Acarina: Eriophyoidea) from West Bengal, India. Entomon, **7** (4): 435–440.

Mohanasundaram, M. 1981. Record of Rhyncaphytoptid gall mites (Rhyncaphytoptidae: Eriophyoidea) from South India. Oriental Ins., **15** (1): 45–55.

Book Review

FUNCTIONAL DYNAMICS OF PHYTOPHAGOUS INSECTS:

Ed. T. N. Ananthakrishnan, Oxford and IBH Publishing Co. Private Ltd., New Delhi-110001: pp viii+304, 1994, Price Rs. 550.00.

The Book presents eleven articles, each giving a complete, uptodate, and critical review of accumulated knowledge on the different aspects of insect-plant relations. In the first article Johnson and Scriber deal with the 'geographic variation in plant allelochemicals of significance to insect herbivores;. The review broadly covers geographic or regional patterns in plant allelochemistry and importance of spatial patterns of variation in plant chemistry to phytophagous insects, using examples from work done on papilionid butterflies and saturnid silk moths. Potential directions for future research are indicated.

Discussing the role of 'phytochemicals as messengers altering behaviour' of insects, Norris concludes that most, if not all, classes of chemicals found in plants contain compounds which serve as messengers in plant-insect interactions. Volatility is the most important property of these chemicals. They function as messengers to alter insect behaviour via a mechanism which is common to all living cells. The electrochemical processes involved in the messenger-receptor interaction are indicated as well as lines for future work.

Ramaswamy, reviewing the works on the "Physiological basis of feeding and oviposition behaviour in moths", finally summarises that recognition and acceptance of host plants by insect requires integration of complex neural and metabolic processes. The author hopes that the information provided in the review of the proximate physiological causes of host finding in moths will aid in explaining moth-host plant interactions.

In the article of Renwick and Huang, the finds on 'interacting chemical stimuli mediating oviposition by Lepidoptera', are reviewed and discussed. They have come to the conclusion that the utilization of plants by lepidopterans is largely determined by the choice of oviposition site by the adult females. The acceptance or rejection of the host plant depends on the insect's assessment of the balance of stimulants and deterrents present on the leaf surface. The dynamic nature of both plant chemistry and insect responses would suggest that environmental changes as a result of biotic or abiotic factors could strongly influence the host selection process. As more of the chemicals involved are identified, the effects of specific environmental changes can be determined and we may be in a position to make predictions about future trends in plant-insect associations, conclude the authors.

Ananthakrishnan *et al.* discussing the finding on the 'energetics and resources allocation in the lepidopteran complex infesting the cotton plant in terms of cultivar diversity and plant chemical quality', high light the role of nutritional suitability of the host in regulating the utilizations and allocation of energy in the insect behavioural diversities are evident as a result of intra-and inter-plant variation in quality of nutrition, water deficiency, ageing and secondary plant substances. A comparative analysis is

given on the influence of plant resistance on nutritional factors and adaptive strategies of the species of caterpillar pest complex in cotton. These and other studies in nutritional ecology have uncovered many links between food attributes, food consumptions and utilization, digestion and subsequent insect performance. The relevance of these studies involving pest-resistant crop varieties is indicated.

As a follow-up of the above chapter, Uthamasamy discusses the intra and interspecific plant behavioural diversity of the caterpillar complex and the important components of the insect-host plant interaction in the following article entitled 'intra-and interplant behavioural dynamics of the cotton bollworm complex'. The role of photoperiod and diapause in the behavioural dynamics of all the bollworm species is also discusses.

Plant chemicals and the location of herbivorous arthropods by their natural enemies' form the subject of review by Whitman and Nordlund. They envisage to tritrophic system consisting of plants, herbivores and natural enemies each subject to selective pressures. The plant produced chemicals play an important role in the host prey selection process for both parasitoids and predators, and the interactions are complex. They may involve release of plant chemicals from the direct mechanical actions of the herbivore or from an indirect herbivore specific physiological response by the plant. Natural enemies may respond to chemicals from the plant or from the herbivore, or to their mixture. The plant derived chemicals released by the herbivores may serve as kairomones for searching carnivores. That certain plants, when attacked by herbivores release volatiles which may induce nearby conspecifics to emit natural enemy attractants is an interesting observation'. The relevance of these investigations in pest management strategies is indicated.

Whitman, Blum and Slansky have synthesized information on 'carnivory in phytophagous insects'. This habit may be an adaptation of compensate for nutritional deficiencies or just a facultative behaviour. The habit of consumption of conspecifics and animal carcass among herbivores is discusses in detail. The taxonomic implication of the phenomenon also is presented.

'Plant bodyguards: mutualistic interactions between plants and the third trophic level', is the topic reviewed and discussed by Whitman. It is pointed out that in the antagonistic interaction between the second and third trophic levels, plants are not simply passing by slanders: they actively assist the natural enemies to attack phytophagous insects. Members of each group of the tritrophic system have been evolving in ratchet-like fashion to the reciprocal adaptations of the others. How plants indirectly influence phytophagous insects by directly influencing the natural enemies is brought out; plant structures and products attract, house, and feed arthropod natural enemies. Such tritrophic interactions range from subtle and haphazard to highly coevolved and interdependent.

Raman reviews the findings on 'adaptational integration between gall-inducing insects and their host plants'. The behavioural dynamics of gall inducing insects as against that of the host plants is analysed. In the evolutionary process the gall phenomenon is preserved to the present time in at least a relatively small number of plant taxa and insects. Coevolutionary possibilities also are indicated. The life-history performances and feeding and ovipositional behaviours of diverse gall insects reviewed against the host and habitat selection processes are quantified in this contribution. It

is pointed out that the study of the interactional process between gall insect and plant still remains a challenge of evolutionary ecologists.

Courtney *et al.* discuss the processes of 'host specificity, meta-population and conservation: *Prosophila magnaguinaria* as a model'. Evidence on several aspects of the biology of the insect is presented. The insect is restricted in its choice of host and host parts and is primarily associated with mating sites rather than simply feeding sites. The dispersal patterns of the insect observed are presented and they support the notion that the insect host interaction varies with patch size. It is concluded that mate location may have important unrecognized consequences for the insect-host interaction.

The introduction of the book contributed by Ananthakrishnan is a precise summary of the eleven chapters. Added components of the book are general index, insect species index and plant species index.

M. R. G. K. Nair

AUTHOR INDEX

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